ISSN 0031-0204

日本古生物学會報告・紀事

Transactions and Proceedings of the Palaeontological Society of Japan

New Series No. 149

日本古生物学会

Palaeontological Society of Japan

April 30, 1988

The fossil on the cover is *Vicarya yokoyamai* Takeyama, an Early Middle Miocene gastropod from the Kurosedani Formation at Kakehata, Yatsuo-cho, Nei-gun, Toyama Prefecture, central Japan (Collected by T. Kotaka and K. Ogasawara, IGPS No. 99075, photo by S. Ohtomo and Y. Kikuchi, x0.9).

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Trans. Proc. Palaeont. Soc. Japan, N.S., No. 149, pp. 361–370, 5 Figs., April 30, 1988

851. EARLY CARBONIFEROUS (VISÉAN) GASTROPODS FROM THE HIKOROICHI FORMATION OF THE KITAKAMI MOUNTAINS, NORTHEAST JAPAN*

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Abstract. Six Early Carboniferous (Viséan) gastropods are described from a sandstone bed of the Hikoroichi Formation exposed in the Onimaru Quarry of Ofunato City, the Kitakami Mountains, northeast Japan. This is the first report of Carboniferous gastropods from the Kitakami Mountains. *Kawanamia* is proposed as a new genus of the family Lophospiridae. The species described herein are *Straparollus* (*Euomphalus*) *asanoi*, n. sp., *S.* (*E.*) sp., *Kawanamia onimarensis*, n. sp., *Baylea yvanii* (Levéillé), *Littorinides* sp., and *Pseudozygopleura* (*Stephanozyga*) *nishimurai*, n. sp. The occurrence of these gastropods suggests Viséan age and supports the previous age assignment of the sandstone bed exposed in the Onimaru Quarry.

Introduction

The biota of the Early Carboniferous Hikoroichi Formation in the Hikoroichi area of the Kitakami Mountains, northeast Japan is highly diverse and has been the subject of a number of works describing or illustrating taxa from it (Minato *et al.*, 1979; Tazawa, 1981, 1984a,b). The formation is about 500 m thick in the type area and consists of such shallow marine sediments as sandstone, slate and impure limestone, which are intercalated with thick tuff beds (Tazawa, 1981; Kawamura, 1983). A richly fossiliferous sandstone bed crops out at the Onimaru Quarry in the Hikoroichi area (Fig. 1). Fossils from this sandstone bed have not yet been fully described, but Tazawa (1984a) reported the occurrence of two *Giganto-productus* species. The bed belongs to Tazawa's (1981, 1984a,b) uppermost part of the Lower Member of the Hikoroichi Formation and to the upper part of Kawamura's (1983) H2 Member of the Hikoroichi Formation.

A large collection from the Onimaru Quarry has been obtained by the efforts of the staff members of the Onimaru Quarry Co. Ltd., and has been made available to specialists for identification and description. Additional material was also collected by myself from 1985 to 1987. The gastropods described in this paper were collected from a fine- to coarse-grained, ill-sorted, tuffaceous sandstone bed, and occurred in association with ubiquitous valves of brachiopods and crinoid stems. These fossils may have been transported for a considerably long distance from their original habitats by bottom currents, since they are commonly fragmented, eroded and arranged parallel to the laminations. Kawamura (1984) has shown that the sandstone of the H2 Member of the Hikoroichi Formation was deposited on a shallow marine bottom around volcanic islands away from continents.

Mollusks are less dominant fossils in the Onimaru Quarry, although a number of gastropod specimens have been collected there. Although the described species are too few, they can nevertheless be used to assess previous age assignments of the bed.

All the specimens used in this paper are housed in the collection of the Section of Invertebrate Paleontology, National Science

*Received October 28, 1987; revised manuscript accepted March 15, 1988; Studies on Japanese Trilobites and Associated Fossils, no. LXIV.

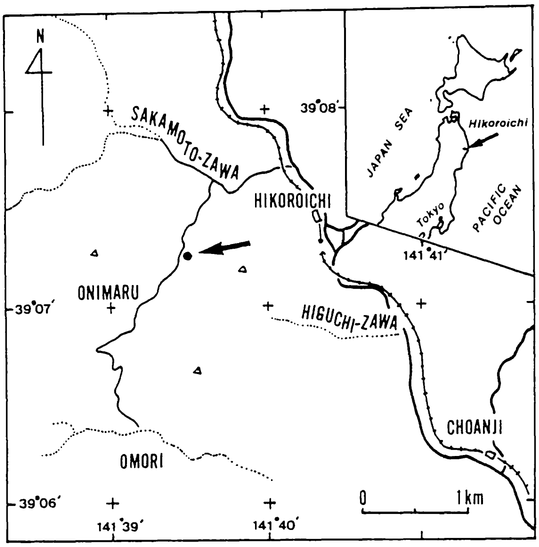

Figure 1. Fossil locality (NSM-PCL6-53-3) in the Hikoroichi area.

Museum, Tokyo.

The gastropod fauna

Six gastropod species described herein are as follows;

Straparollus (*Euomphalus*) *asanoi*, n. sp.
Straparollus (*Euomphalus*) sp.
Kawanamia onimarensis, n. gen. and n. sp.
Baylea yvanii (Levéillé)
Littorinides sp.
Pseudozygopleura (*Stephanozyga*) *nishimurai*, n. sp.

I also found four additional species, *Bellerophon*? sp., *Retispira* sp., pleurotomariacean gen. et sp. indet., and *Platyceras* sp., but they are too poorly preserved to describe.

One is referred to *Baylea yvanii* (Levéillé), which has been known to occur from the Tournaisian of Belgium, the lower Viséan of Wales and the Lower Carboniferous of England (Batten, 1966). Among five other species, *Straparollus* (*Euomphalus*) *asanoi*, n. sp. has a close relationship to *Straparollus* (*Euomphalus*) *acutus* (Sowerby) known from the Viséan of the western Europe (Batten, 1966). Species of *Littorinides* and *Pseudozygopleura* (*Stephanozyga*) are also known to occur from the Viséan of western European regions. These records suggest a Viséan age for the sandstone bed in the Onimaru Quarry.

Recent paleontological studies have indicated that the Hikoroichi Formation ranges from the late Tournaisian to Viséan (Mori and Tazawa, 1980; Tazawa, 1981, 1984a, b; Kawamura, 1983). Based on the occurrence of two *Gigantoproductus* species from the same sandstone bed in the Onimaru Quarry, Tazawa (1984a) dated it as the Viséan. The occurrence of the gastropods described herein supports these age assignments.

Systematic description

Superfamily Euomphalacea
Family Euomphalidae
Genus *Straparollus* de Montfort, 1810
Subgenus *Euomphalus* J. Sowerby, 1814
Straparollus (*Euomphalus*) *asanoi*, n. sp.

Figures 2-1–4

Diagnosis: A large and trochiform *Straparollus* (*Euomphalus*) having a weakly stepped and concave to flat subsutural ramp with maturity, a rather narrow umbilicus and a trapeziform whorl section of body whorl. Spiral angulation on upper whorl surface thick and round-topped, with deep sinuation on it.

Description: Large trochiform euomphalids with shell height about 3/5 of shell diameter and with height of spire slightly smaller than 1/2 of shell height. Pleural angle in later spire whorls about 90°. Protoconch not preserved. Early whorls with regularly rounded upper whorl surface. Sutures impressed. A weak spiral angulation positioned at midwhorl on last three whorls in mature specimens, then it becoming stronger toward body whorl. Body whorl with an obtuse trapeziform whorl section. Upper whorl surface with flat to weakly concave subsutural ramp being delimited by a round-topped, thick spiral angulation. Basal periphery of body whorl obtusely angulated and whorl surface between the spiral angulation and basal periphery steeply inclined and slightly flattened. Base rather narrowly phaneromphalous and weakly convex,

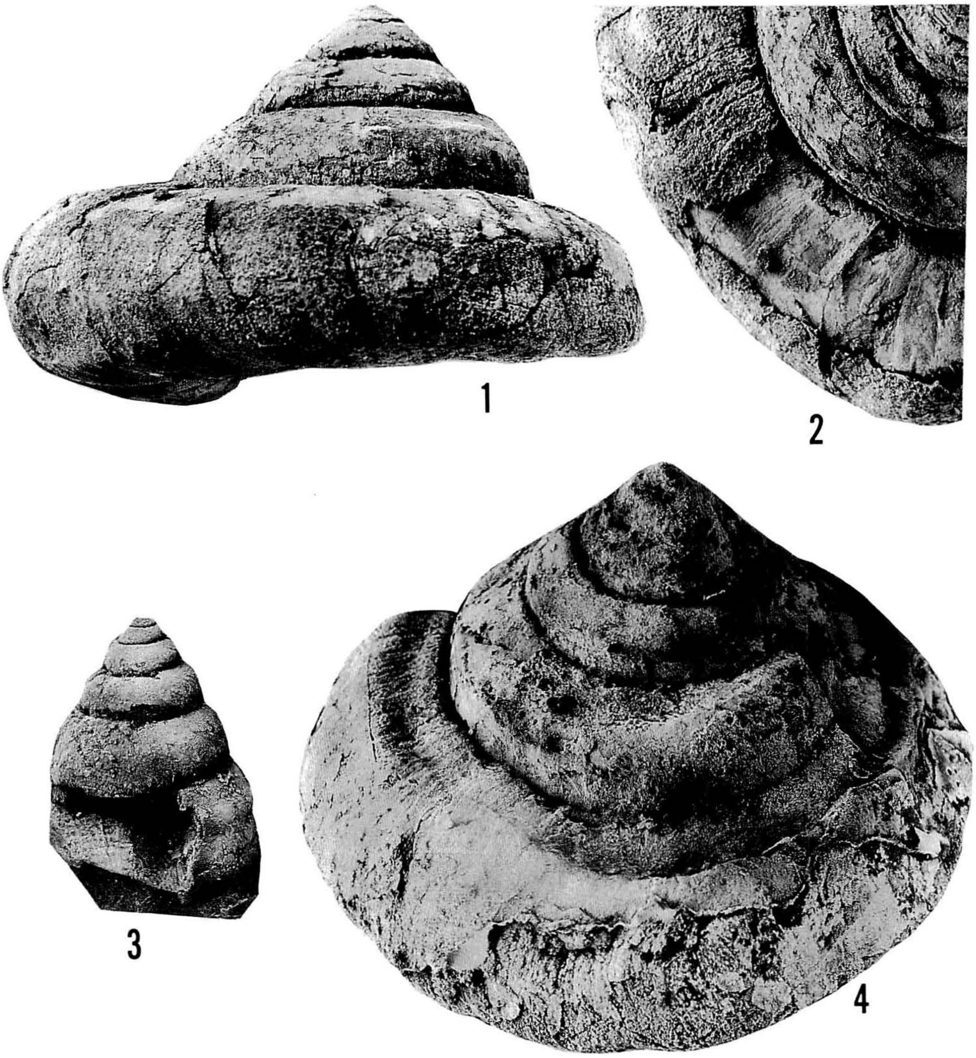

Figure 2. *Straparollus* (*Euomphalus*) *asanoi*, n. sp. 1, apertural view of the holotype, NSM-PM15385, shell diameter, 88.4 mm, height, 53.5 mm, x 1.0; 2, top surface of the holotype showing the dorsal sinus and growth lines, x 1.0; 3, lateral view of a paratype, NSM-PM15387 showing early whorl profile, shell diameter, 27.9 mm, height, 27.5 mm, x 1.0, this specimen is strongly distorted laterally so that the apical angle is smaller than the original; 4, oblique view of a paratype, NSM-PM15386, shell diameter, 93 mm, height, ca. 55 mm, x 0.95, the spiral angulation on the right half of the body whorl is accentuated by diagenetic deformation.
All specimens are silicon rubber casts.

with roundly convex umbilical wall. Umbilical sutures impressed. Width of umbilicus about 1/3 of base diameter. Shell surface ornamented entirely by rugose growth lines; these lines being orthocline on upper whorl surface above spiral angulation, rather deeply sinuous on spiral angulation, then bending prominently to become prosocyrt on upper whorl surface below spiral angulation. Growth lines also gently curving to become prosocline across basal periphery and into umbilicus, then turning to curve orthocline toward umbilical sutures.

Discussion: In the general outline, *Straparollus* (*Euomphalus*) *asanoi* closely resembles

Straparollus (*Euomphalus*) *acutus* (Sowerby, 1818) from the Viséan of Belgium, England, Ireland and Germany (de Koninck, 1881; Batten, 1966). *S.* (*E.*) *asanoi* also has an ontogenetic change of whorl profile similar to that of *S.* (*E.*) *acutus;* both species have a roundly convex whorl surface in the early growth stage and have a spiral angulation at midwhorl in the later growth stage. However, the size of *S.* (*E.*) *asanoi* is more than three times that of *S.* (*E.*) *acutus.*

Straparollus (*Euomphalus*) *asanoi* resembles *Euomphalus crotalostomus* (M'Coy, 1844), (de Koninck, 1881) from the Viséan of Ireland and Belgium in shell size and characteristics of whorl shape. The Hikoroichi species is distinct as the height-to-width proportion is much larger than that of *E. crotalostomus.*

Straparollus (*Euomphalus*) *asanoi* also resembles *Omphalotrochus kalmiussi* Zernetskaja (1967) from the lower Viséan of Donetz Basin, U.S.S.R., but differs in having a more adaxially located spiral angulation on the upper whorl surface than the latter species.

Etymology: This species is named after Mr. T. Asano who donated his collection to the National Science Museum, Tokyo.

Figured specimens: Holotype, NSM-PM15385; paratypes, NSM-PM15386, 15387.

Straparollus (*Euomphalus*) sp.

Figures 3-4,5

Discussion: This species is found commonly in the Onimaru Quarry. The specimens show depressed discoidal shell outline. They also have angulated upper whorl surface and rounded lower whorl surface. The spiral angulation on the upper whorl surface seems to appear in the later growth stage. The maximum shell diameter is 40 mm in the largest specimen. Although most of the specimens of this species are severely distorted to make comparison with other species difficult, they differ definitely from *S.* (*E.*) *asanoi* in its small shell size and in having planispiral shell form.

Figured specimens: NSM-PM15394, 15395.

Superfamily Pleurotomariacea
Family Sinuopeidae
Subfamily Omospirinae
Genus *Baylea* de Koninck, 1883
Baylea yvanii (Levéillé, 1835)

Figures 3-1,6–9

Trochus yvanii Levéillé, 1835, p. 39, pl. 2, fig. 24.
Pleurotomaria yvanii: de Koninck, 1843, p. 390, pl. 37, figs. 1, 7.
Baylea yvanii: de Koninck, 1883, p. 69, pl. 27, figs. 1–5, pl. 32, figs. 8, 9; Knight, 1941, p. 51, pl. 21, figs. 1a–c; Batten, 1966, p. 25, pl. 3, fig. 4; Peel, 1985, p. 104, pl. 6–6–18.
Yvania yvanii: Fischer, 1885, p. 851.
Baylea communis de Koninck, 1883, p. 70, pl. 27, fig. 11.
Baylea spirata de Koninck, 1883, p. 71, pl. 32, fig. 10.
Baylea duplicosta de Koninck, 1883, p. 71, pl. 25, figs. 11, 12.
Baylea leveillei de Koninck, 1883, p. 73, pl. 27, figs. 6–10.
Baylea simplex de Koninck, 1883, p. 74, pl. 27, figs. 12–15.

Description: Shell thin, gradate and turbiniform, with height greater than width. Height of spire about 1/2 of total shell height. Pleural angle about 80°. Protoconch and earlier teleoconchs not preserved. Sutures distinct, not impressed. Spire whorls prominently keeled at midwhorl, with a gently inclined and weakly concave upper whorl surface and vertical outer whorl surface. Body whorl also possessing a broad, gently inclined and concave upper whorl surface; its outer whorl surface having a vertical and very slightly concave area just below shouldered edge, then it becoming convex at basal periphery. Base regularly convex, with a tiny umbilical chink. Aperture subquadrate in shape, being acutely angled above and broadly rounded below. Outer lip thin and angularly convex. Inner lip regularly concave and slightly reflexed. Basal lip roundly concave and very slightly reflexed. Surface with fine, sharp and rather regularly spaced spiral cords and with some subordinate ones in their interspaces; spiral cords numbering from four to six on upper whorl surface and about 15 at base, respectively; outermost spiral cord on upper whorl surface being stronger than others.

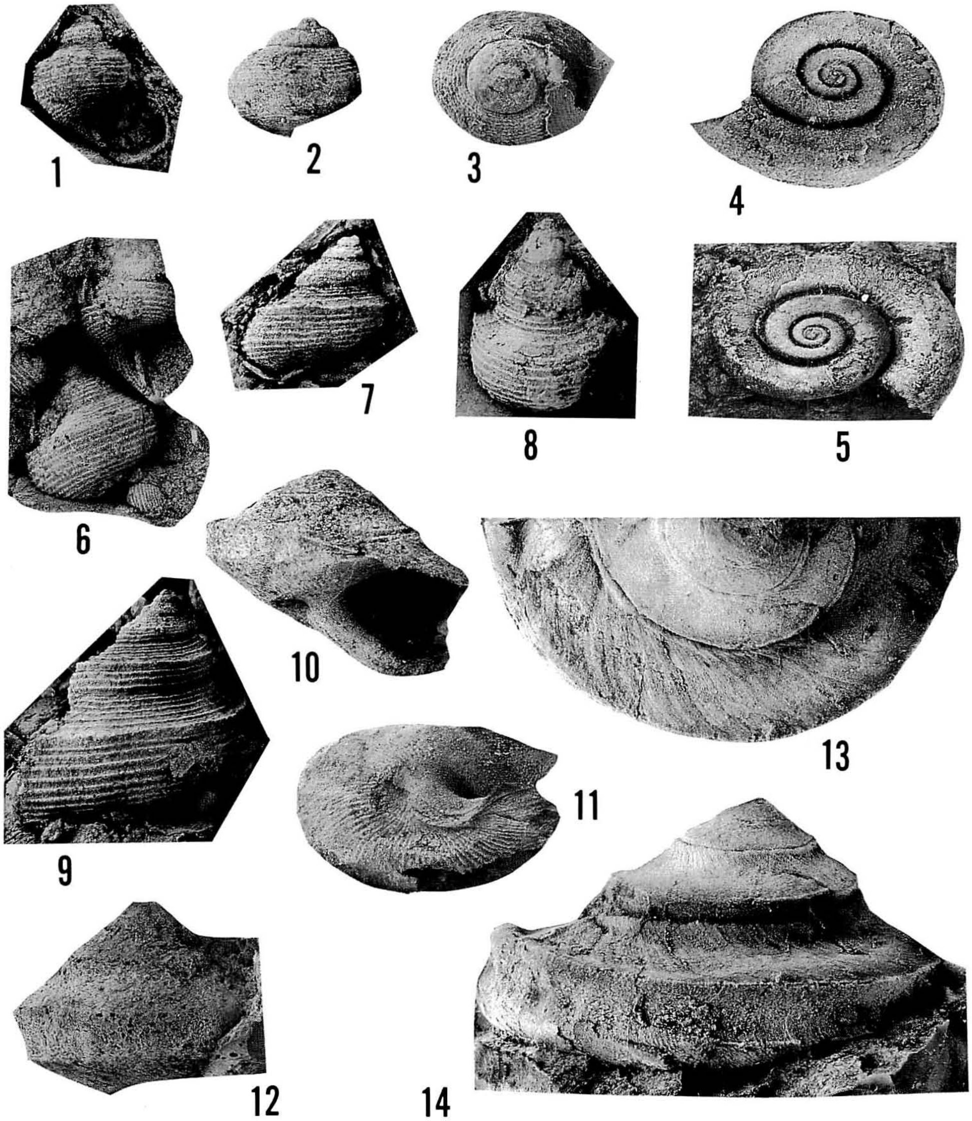

Figure 3. 1, 6–9 *Baylea yvanii* (Levéillé). 1, apertural view of a specimen, NSM-PM15388, shell diameter, 13.4 mm, height, 13.5 mm, x 1.35; 6, apertural views of two specimens, NSM-PM15389, x 1.5; 7, adapertural view of a specimen, NSM-PM15390, shell diameter, 12.5 mm, height, 13.5 mm, x 1.5; 8, oblique view of a specimen, NSM-PM15391, shell diameter, 14.5 mm, x 1.5; 9, adapertural view of the largest specimen, NSM-PM15392, shell diameter, 20.0 mm, x 1.5. 2, 3, *Littorinides* sp., apertural and apical views of a specimen, NSM-PM15393, shell diameter, 14.5 mm, height, 11.0 mm, x 1.5. 4, 5, *Straparollus* (*Euomphalus*) sp. 4, apical view of a distorted specimen, NSM-PM15394, maximum shell diameter, 23.3 mm, x 1.5; 5, apical view of a distorted specimen, NSM-PM15395, maximum shell diameter, 22.4 mm, x 1.5. 10–14, *Kawanamia onimarensis*, gen. et sp. nov. 10, 11, apertural and basal views of the holotype, NSM-PM15396, showing characteristics of basal ornamentation and columellar lip, maximum shell diameter, 24.5 mm, height, 18.6 mm, x 1.4; 12, lateral view of a paratype, NSM-PM15397, x 1.4; 13, 14, apical and lateral views of a paratype, NSM-PM15398, showing the shallow V-shaped sinus at the upper whorl angulation, shell diameter, 62.3 mm, x 1.0.
All specimens are silicon rubber casts.

Selenizone seemingly located just above shouldered angulation, delimited by outermost spiral cord and shouldered edge, and represented by a wide, very gently inclined concave depression; one or two very fine spiral cords present within the selenizone.

Discussion: This species is found commonly in the Onimaru Quarry. Specimens of this species all occur as a slightly distorted external mold. The upper whorl surface is ornamented by spiral cords numbering from four to six; the outermost one is most prominent. In their interspaces, there are one or two very fine spiral cords. Although the coarse-grained nature of the matrix is not suitable to show delicate characteristics of the selenizone, the selenizone appears to be positioned between the outermost spiral cord and shouldered angulation. The presence of a very fine spiral cord in the selenizone is also known in the European specimens of *Baylea yvanii* (*e.g.*, Knight, 1941, pl. 21, fig. 1b).

The Hikoroichi specimens can be referred to *Baylea yvanii* (Levéillé, 1835) which is known to occur from the Tournaisian of Belgium, the Lower Carboniferous of England and the lower Viséan of Wales (Batten, 1966, p. 26). Batten (1966) stated that *B. yvanii* shows a large variation in form as to the height of spire and the rapidity of whorl expansion among Belgian specimens and synonymized other five *Baylea* species described by de Koninck (1883) with *B. yvanii.* As to the shell outline, the Hikoroichi specimens seem to fall within the range of variation of *B. yvanii.*

Figured specimens: NSM-PM15388-15392.

Family Lophospiridae
Subfamily Lophospirinae
Genus *Kawanamia*, n. gen.

Type species: *Kawanamia onimarensis*, sp. nov.

Diagnosis: Large, anomphalous and low turbiniform shell with a biangulated outer whorl surface. Ramp broad, gently inclined and more or less concave. Labral sinus culminating at upper keeled angulation in a shallow V-shaped notch. Base evenly convex, but shallowly depressed around columella with an obtuse angulation around it. Parietal area covered by thin callus. Columellar lip wide, semilunar in form and reflexed. Ornamentation consisting of fine lirae on subsutural area and over base.

Discussion: *Kawanamia* is erected for only the type species. The shape of the whorl and the V-shaped shallow notch at the upper whorl angulation simulate those of *Lophospira,* but its low turbiniform shell shape readily distinguishes from *Lophospira.* Superficially, *Kawanamia* resembles *Trochonema* and *Trochonemopsis* in shell form, but differs in having the V-shaped labral notch at the upper whorl angulation and in lacking a deep umbilicus.

Etymology: The genus is named after Mr. T. Kawanami, Director of the Onimaru Quarry Co. Ltd., who donated his collection to the National Science Museum, Tokyo and enabled me to collect the material from that quarry.

Kawanamia onimarensis, n. sp.

Figures 3-10–14; 4

Diagnosis: Same as for the genus.

Description: Large, anomphalous and low turbiniform shells with height slightly greater than width. Spire low conical with height about 2/5 of total shell height. Protoconch and early whorls not preserved. Spire whorls embracing previous one just below the upper angulation, but the area of inpingement moving downward in final whorl. Spire whorl surface broad, gently

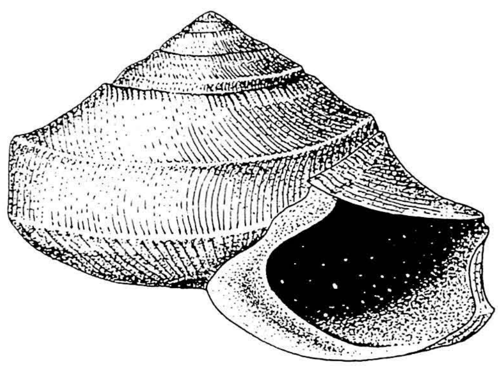

Figure 4. Reconstruction of *Kawanamia onimarensis*, n. gen. and n. sp. (x ca. 1).

inclined, weakly concave and flushed. Body whorl with a broad and concave ramp and a biangulated outer whorl surface; the upper angulation being more acute than the lower one whose position being situated slightly above rounded basal periphery; outer whorl surface vertical and concave. Base with evenly convex surface in main part, but the area around columella shallowly depressed with an obtuse angulation at abaxial margin. Aperture weakly tangential to body whorl and subquadrangulate in outline. Parietal callus thin and extending slightly from inside the aperture. Columellar lip wide, semilunar in shape and reflexed.

Upper whorl surface ornamented by fine, prosocline lirae that follow growth lines, arise at the upper suture and die out at the middle of upper whorl surface; they become obsolete in the final whorl. Base covered by fine, sinuous lirae. Growth lines fine, steeply prosocline on the upper whorl surface, forming an acute sinus at upper angulation, then curving to form a vertical and roundly prosocyrt trend on the outer whorl surface; the growth lines on base widely opisthocyrt on the main part and turning to sinuate around the columella.

Discussion: Comparison of this species with related forms is made in the discussion part of the genus.

Figured specimens: Holotype, NSM-PM15396; paratypes, NSM-PM15397, 15398.

Superfamily Neritacea
?Family Plagiothyridae
Genus *Littorinides* Knight, 1937
Littorinides sp.

Figures 3-2,3

Discussion: One specimen is referrable to *Littorinides,* but it is not enough to ascertain its specific identity. Although no aperture is preserved in this specimen, its shell size, shell outline and surface ornamentation are quite similar to those of *Littorinides solidum* (de Koninck, 1843), the type species of the genus, described from the Lower Carboniferous of Belgium, which was redescribed and illustrated by Knight (1941, pl. 82, figs. 1a,b). The Hikoroichi taxon differs from *L. solidum* in having coarser spiral cords.

The shell is small in size and turbiniform, and has well inflated whorls that are separated by impressed sutures. The whorl inflation is weak in the upper whorl surface and strong at the base. The surface ornamentation consists of fine, sharp spiral cords and prosocline growth lines. The growth lines are very finely granulated at place where these spiral cords intersect.

Figured specimen: NSM-PM15393.

Superfamily Loxonematacea
Family Pseudozygopleuridae
Genus *Pseudozygopleura* Knight, 1930
Subgenus *Stephanozyga* Knight, 1930
Pseudozygopleura (*Stephanozyga*) *nishimurai*, n. sp.

Figures 5-1–3

Diagnosis: A very large species of *Pseudozygopleura* (*Stephanozyga*) having higher proportion of whorl and slightly opisthocline collabral ribs. Whorls adpressed. Number of ribs about 14 on each whorl.

Description: Shell attains more than 15 cm in height, high spired, with apical angle of about 20°. Protoconch and early whorls unknown. Whorl profile asymmetrically inflated, slightly concave from suture to upper one-third of whorl, then it gradually becoming convex downward; the highest point located at lower one fifth of whorl. Early whorls adpressed, but suture gradually becoming deeper between later whorls. Preserved early four whorls in the holotype seemingly smooth, with whorl profile similar to that of later whorls, with axial ribs appearing in the fifth whorl. Curvature of the upper whorl surface of body whorl similar to that of previous whorls, with weakly convex and steeply inclined base, no detectable angulation occurring between outer whorl surface and base. No umbilicus. Outer lip and anterior extremity poorly preserved, but the former widely convex and the latter weakly projected anteriorly to form an ill-defined anterior sulcus. Columellar lip almost

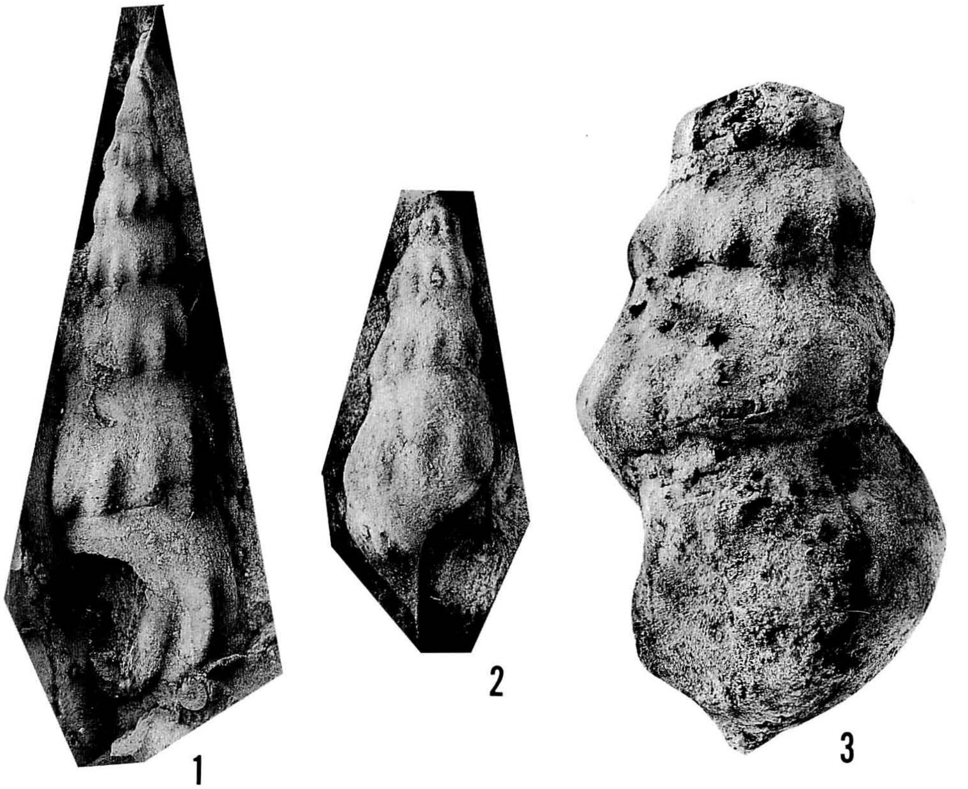

Figure 5. *Pseudozygopleura (Stephanozyga) nishimurai,* n. sp. 1, lateral view of the holotype, NSM-PM15399, showing early four smooth and later six strongly ribbed whorls, height, ca. 89 mm × 1.0; 2, apertural view of a paratype, NSM-PM15400, showing the reflexed columellar lip, shell diameter, 22.7 mm, height, 57.5 mm, × 1.0; 3, lateral view of a large paratype, NSM-PM15401, showing the ribbed spire whorls and the smooth body whorl, shell diameter, 48.3 mm, height, 83.0 mm, × 1.0.

straight, vertical and reflexed. Surface sculptured by collabral ribs and very fine growth lines. Ribs strong, 14 in number in each whorl of the holotype, more or less aligned in vertical rows from whorl to whorl, very slightly opisthocline and sinuous, round-topped, slightly narrower than their interspaces, suppressed above and below, and seemingly missing or very weak in body whorl of adult specimens. Growth lines orthocline for a short distance below upper suture, then turning to opisthocyrt below.

Discussion: This species is represented by five incomplete external molds. They are considerably distorted by diagenetic compression except for the holotype, so that they show slightly wider shell profile than their original state. The holotype preserves four early smooth whorls and six strongly ribbed spire whorls. Characteristics of the whorl profile, collabral ribs and sutures are clearly represented in this specimen. Two large and probably mature specimens, although they are poorly preserved, possess a seemingly smooth body whorl. The loss of ribs, costae or nodes at this point is also known in such species as *Pseudozygopleura (Stephanozyga) rugifera* (Phillips, 1836), (Longstaff, 1933, pl. 7, fig. 7), *P. (S.) subnodosa* Knight (1930), and *Loxonema murchisonianum* de Koninck (1843), (de Koninck, 1881).

The size of this species reconstructed from the large and small specimens may attain more than 15 cm in height. This species is the largest among the members of *Stephanozyga* and can be distinguished from all other species primarily by its large shell size. *Pseudozygopleura* (*Stephanozyga*) *nishimurai* resembles *P.* (*S.*) *rugifera* from the Lower Carboniferous of the United Kingdom and Belgium, but the loss of collabral ribs in the body whorl of the specimen illustrated by Longstaff (1933) suggests that *P.* (*S.*) *rugifera* is much smaller than *P.* (*S.*) *nishimurai* even in its adult stage. Furthermore, *P.* (*S.*) *nishimurai* has much stronger collabral ribs than *P.* (*S.*) *rugigera.*

Pseudozygopleura (*Stephanozyga*) *nishimurai* resembles *Pseudozygopleura magna* Wang (1987) from the Lower Carboniferous of Guizhou, China, but differs from the latter in its much larger shell size and in having coarser axial ribs on the spire whorls. *P.* (*S.*) *nishimurai* is also distinguished from *P.* (*S.*) *nodosa* (Girty, 1915) and *P.* (*S.*) *subnodosa* Knight (1930), both from the Upper Carboniferous of Missouri, primarily by its much larger shell size.

Etymology: This species is named after Mr. S. Nishimura who donated his collection to the National Science Museum, Tokyo.

Figured specimens: Holotype, NSM-PM15399; paratypes, NSM-PM15400, 15401.

Acknowledgments

Messrs. T. Kawanami, T. Asano, S. Nishimura and S. Kinno generously donated their collections to the National Science Museum, Tokyo. I thank Messrs. T. Ono, A. Kaneko and S. Niko for their help in the field. I also thank Dr. K. Uemura who reviewed the manuscript.

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Ofunato 大船渡, Onimaru 鬼丸, Hikoroichi 日頃市.

東北日本北上山地の日頃市層産石炭紀前期（ビゼー世）腹足類：東北日本北上山地，大船渡市の鬼丸採石場に露出する日頃市層の砂岩より6種の腹足類を記載した。これらは北上山地では初めて記載された石炭紀の腹足類である。*Kawanamia* 属は Lophospiridae 科の新属として記載した。記載した種は *Straparollus* (*Euomphalus*) *asanoi*, n. sp., *S.* (*E.*) sp., *Kawanamia onimarensis*, n. gen. and n. sp., *Baylea yvanii* (Léveillé), *Littorinides* sp.と *Pseudozygopleura* (*Stephanozyga*) *nishimurai*, n. sp. である。これらのうちの一種はベルギーのトルネー世とイギリスのビゼー世から知られている *Baylea yvanii* に同定され，*S.* (*E.*) *asanoi* はベルギー，ドイツ，イギリスとアイルランドのビゼー世に知られる *S.* (*E.*) *acutus* (Sowerby)に近縁と考えられる。これらの腹足類の産出は鬼丸採石場の日頃市層の砂岩がビゼー世であることを暗示し，従来のこの砂岩の時代論を支持する。 加瀬友喜

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 149, pp. 371–377, 3 Figs., April 30, 1988

852. *FISHERITES*, A RECEPTACULITID FROM THE MIDDLE ORDOVICIAN OF PYONGYANG COAL-FIELD*

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Abstract. A single specimen of Middle Ordovician receptaculitid from the Josen Supergroup of North Korea was previously called as *Receptaculites coreanicus* Ikebe (nom. nud.) by Ikebe in 1939. We reinvestigated the specimen, and found that it was a new species of the genus *Fisherites*, *F. coreanicus* Niko and Ikebe on account of having relatively large thallus and asymmetrical intercalary meroms.

Introduction

Receptaculitids are problematic organisms of Early Ordovician to Devonian, possibly of late Paleozoic, possessing discoidal to columnar skeletons consisting of the assemblages of meroms. Since the beginning of the nineteenth century, this organism has been interpreted in various ways by various authors as algae, pine cones, foraminifers, sponges, corals, cystoids, tunicates, transitional form between sponges and corals, or an independent extinct phylum (Kesling and Graham, 1962), however, an algal hypothesis becomes prevailing after Kesling and Graham (1962), Byrnes (1968), Nitecki (1969, 1970, 1972) and Rietschel (1969, 1977). The purpose of this paper is to describe the morphology of a Middle Ordovician receptaculitid specimen from the Pyongyang Coal-field.

The Pyongyang Coal-field occupies a large area of North Korea with Precambrian and Lower Paleozoic basement, which is composed mostly of Archeozoic gneisses, the Upper Proterozoic Sangweon Group and the Cambro-Ordovician Josen Supergroup. The receptaculitid described here was collected by Ikebe in 1936 from the uppermost part of the Josen Supergroup, and was documented only in a report of geological investigation of eastern district of the Pyongyang Coal-field under the name of *Receptaculites coreanicus* (Ikebe, 1939; Ikebe in Nakamura *et al.*, 1957). The original specimen, which has been deposited in the paleontological collection of Kyoto University, is restudied here and assigned to the genus *Fisherites* Finney and Nitecki, 1979.

Receptaculitids are rare to occur in Far East Asia, and so far as we know there are only two published records of receptaculitids besides our specimen; they are *Calathium frechi* Endo, 1932 from the Santao Formation (Canadian, Early Ordovician) in the Liaoning Province, of Northeast China and *Receptaculites* sp. (Hamada and Itoigawa, 1983) of the Lower (to Middle?) Devonian Fukuji Formation, central Japan.

The specimen described in this paper is

*Received June 25, 1987; revised manuscript accepted March 15, 1988

registered and deposited in the Department of Geology and Mineralogy, Faculty of Science, Kyoto University (KUJP).

Geological setting and fossil occurrence

The Cambro-Ordovician sequence, which is composed mainly of carbonate rocks with subordinate amounts of shale and quartzite, is called collectively the Josen Supergroup in Korea, and is commonly divided into two major types on the basis of their rock types and faunas, *i.e.,* the Duwibong-type sequence and the Yeongweol-type sequence (Kobayashi, 1928, 1966; Yosimura, 1940). The Duwibong-type Josen Supergroup is characterized by continental shelf deposits. On the other hand the Yeongweol-type was formed in the axial region of the Ogcheong basin and contains Chiangnan type fauna of South China (Kobayashi, 1967). The Josen Supergroup in the Pyongyang Coal-field, from which the receptaculitid fossil was collected, belongs to the Duwibong-type sequence including faunas with the Hwangho affinity of Northeast China.

Fisherites coreanicus occurs with *Actinoceras* sp. in the weakly recrystallized and dolomitized limestone (peloidal grainstone) of the uppermost Josen Supergroup at the locality 1.4 km south of Samtung (Figure 1). Geology and stratigraphy of this area were described by Ikebe (1939) and Nakamura *et al.* (1957) in detail. According to them, the Ordovician sequence of the Josen Supergroup is made up of, in ascending order, the Kotyongsan Formation, the Sanbatsmol Formation and the Kangjinsan Formation, in which the fossil site lies in the middle part. The equivalent strata (Unhak Formation) of the Mt. Mantal area with the Kangjinsan Formation contains many cephalopods including *Actinoceras, Armenoceras, Stereoplasmoceras, Vagino-*

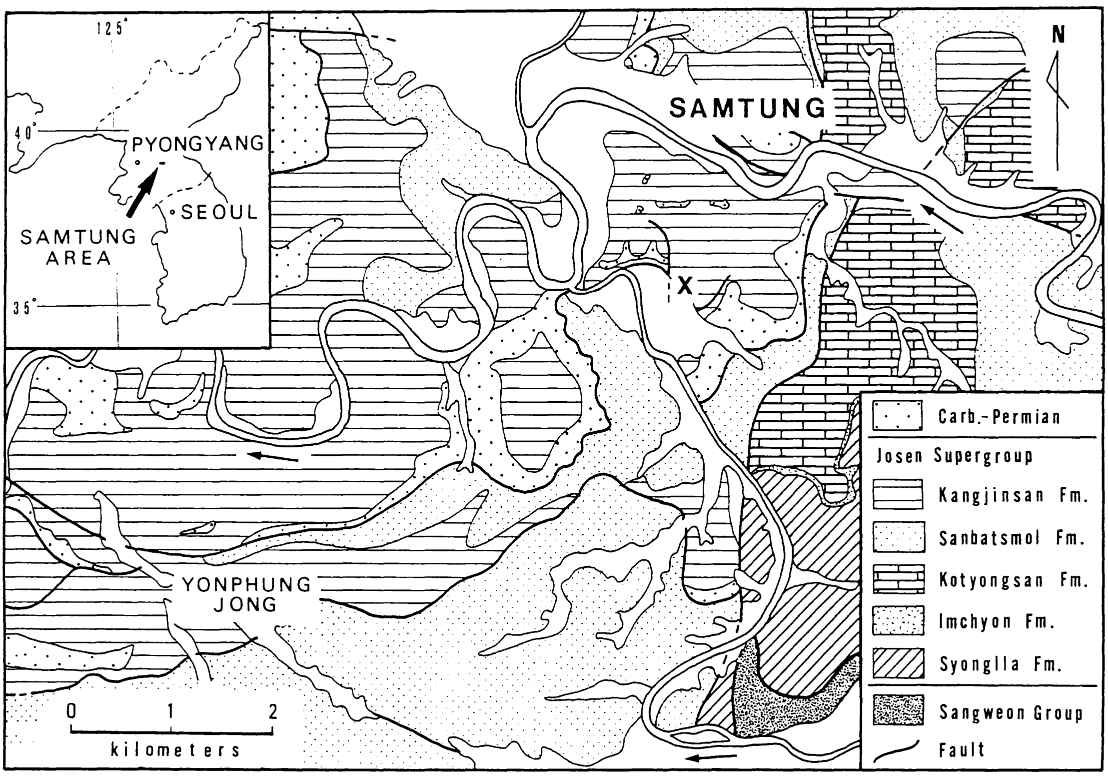


Figure 1. Map showing collecting locality (X), and geology of the Samtung area, North Korea (modified from Ikebe, 1939).

ceras and others (Kobayashi, 1928, 1929, 1930), gastropods (Kobayashi, 1929, 1930) and stromatoporoids (Yabe and Sugiyama, 1930). As noted by Kobayashi (1929, 1930), this fauna shows an affinity to the Toufangkou fauna and Machiakou fauna of Northeast China. Biostratigraphically the Kangjinsan Formation spans from the late Chazyan to the Ashbyan age, Middle Ordovician.

Systematic paleontology

Class Receptaculitaphyceae Weiss, 1954

Order Receptaculitales James, 1885

Family Receptaculitaceae Eichwald, 1860

Genus *Fisherites* Finney and Nitecki, 1979

Fisherites coreanicus Niko and Ikebe, sp. nov.

Figures 2-1–3; 3-A–D

1939 *Receptaculites coreanicus* Ikebe (nomen nudum), p. 436.

1957 *Receptaculites coreanicus* Ikebe. Nakamura, Matsushita, Kobatake and Ikebe, p. 13 (listed).

Etymology:—The specific name is derived from Korea.

Diagnosis:—Medium- to small-sized species of *Fisherites* characterized by possessing subglobular thallus with small corniculum, inflated proximal end of merom shafts and three distinct types of intercalation of meroms.

Material:—Description of this new species is based upon only a single deformed specimen (KUJP 10201) in which no lacunar hemisphere is preserved.

Terminology:—The terminology in this paper follows Fisher and Nitecki (1982).

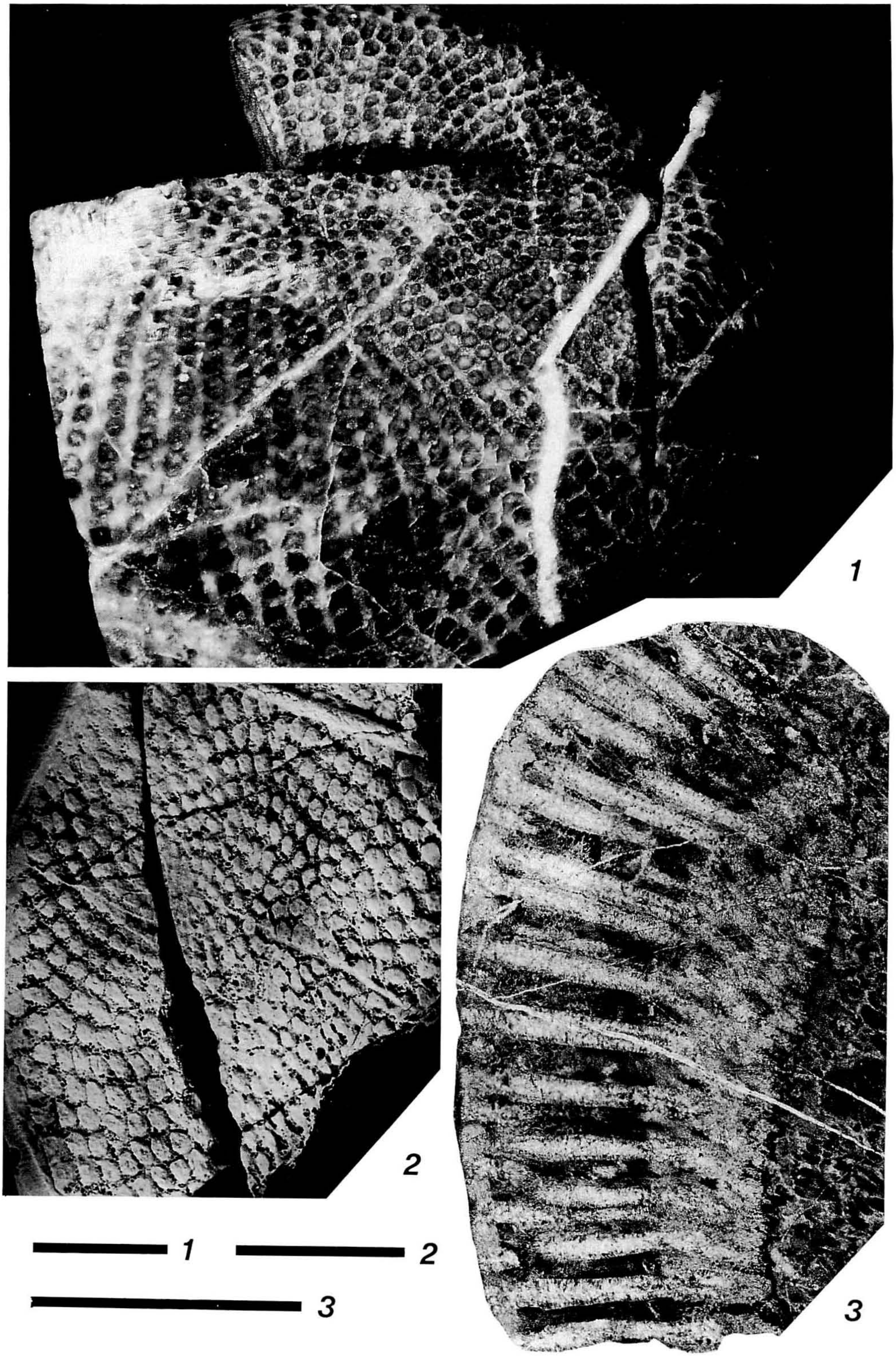
Description:—Thallus: Thallus is medium- to small-sized for the genus. The preserved portion of nuclear hemisphere is shallow dish shape, approximately 6.0 cm x 4.7 cm across. The nucleus and its immediate vicinity area of approximately 4 mm in diameter are missing. However, we can assume that there was a small corniculum at the nuclear part, because of a weak projection of inner wall is recognized at the suspected point.

Meroms: Meroms are arranged in circlets around a reconstructed nucleus. Each merom is divided into head and shaft, and individual heads consist of thick and rhomboidal plates, which form the outer wall with the juxtaposition of adjacent meroms and four ribs of stellate structure. Ribs are short and stout. Among themselves the abapical medional ribs are situated nearest the outer wall. The proximal ends of columnar shaft are inflated and form a thick inner wall. The size of shaft and head decreases toward the nucleus; the length of the merom attains 15.0 mm at least. Small elliptic perforations are recognized on a diagonal line of the plate. Each merom is enveloped in a dark thin micritic layer (Hüllschicht; Rietschel, 1969), and its inner part consists of sparry calcite. Except for the meroms, intervallum is filled with the sediment (Figure 2-3).

Intercalation of meroms: The merom heads are not preserved in the vicinity of nucleus because of weathering, nevertheless it is possible that the plate boundaries are reconstructed employing a pattern of merom shafts. In this specimen, three distinct types of intercalation are distinguishable; (1) a symmetrical intercalation at normal interpositum and triangulum (Figure 3-A); (2) a symmetrical intercalation at interpositum-triangulum triplet (Figure 3-B); and (3) an asymmetrical intercalation (Figures 3-C, D).

The latitudinal distribution of those types is almost mutually exclusive. There are 6 (+3?) visible pairs of the normal interpositum and triangulum causing a symmetrical intercalation, and they appear to be restricted to the vicinity of nucleus. The interpositum-triangulum triplets are distributed more lacunarward of the thallus than normal one; and their visible numbers are 9 (+3?). The latitudinal distribution of asymmetrical intercalations is confined to over a distance of approximately 24 mm from the suspected nucleus; there are 2 asymmetrical intercalary parastichies, of which direction is opposite

Discussion:—The present specimen is referred to *Fisherites* Finney and Nitecki, 1979 on account of a relatively large thallus among the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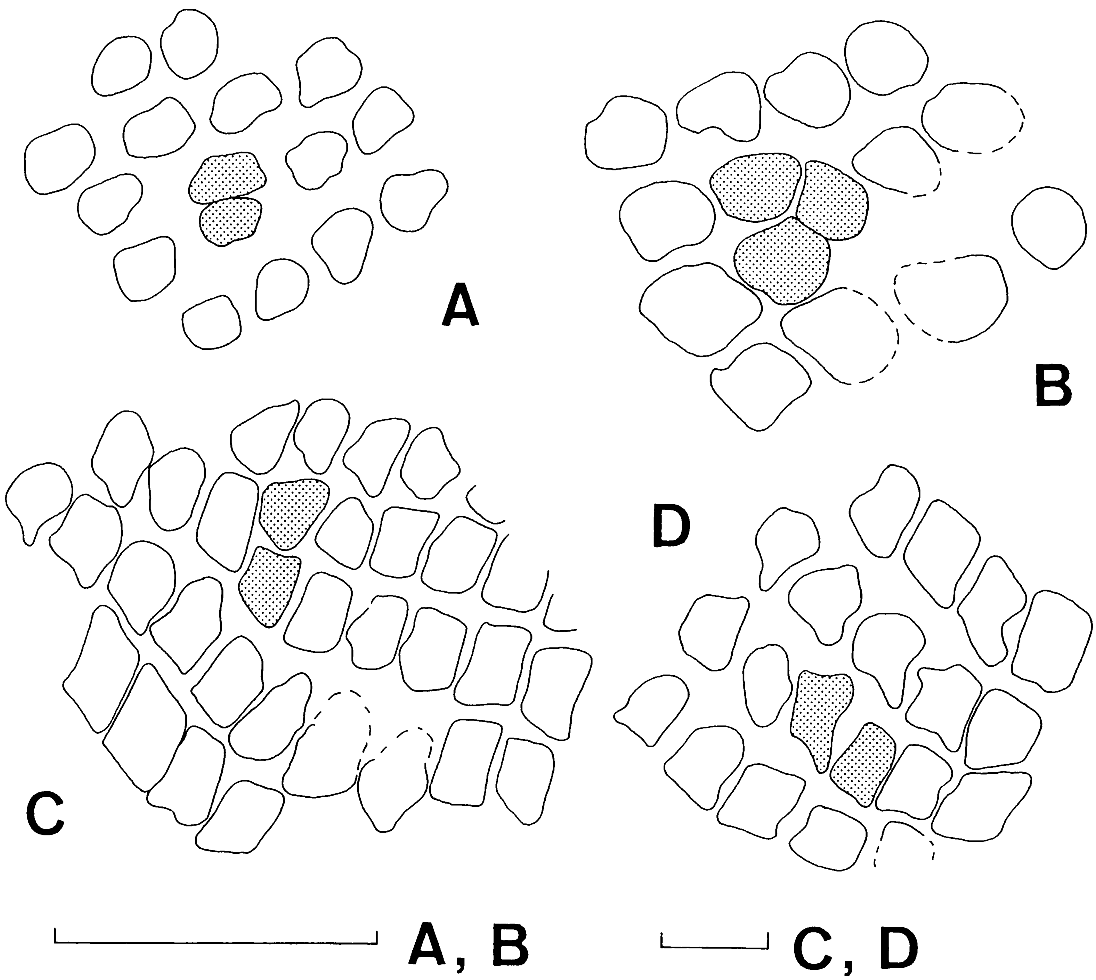

Figure 3. Intercalation in *Fisherites coreanicus* Niko and Ikebe, sp. nov., camera lucida drawing of plate boundaries or outline of merom shafts in the neighbourhood of intercalation. Interposita, triangula and the initial plates of asymmetrical intercalary parastichies are indicated by stipling.
A, interpositum-triangulum pair. B, interpositum-triangulum triplet. C, asymmetrical intercalation of sinistral direction. D, asymmetrical intercalation of dextral direction. All bar scales equal 4mm.

known receptaculitids and having the asymmetrical intercalary meroms. As noted by Fisher and Nitecki (1982) in *Fisherites occidentalis* (Salter), *F. reticulatus* (Owen) and *Calathium egerodae* Nitecki, the cooccurrence of both symmetrical and asymmetrical intercalation is recognized in the examined specimen.

Fisherites coreanicus, sp. nov. is somewhat similar to *F. occidentalis* (Salter) (Hinde, 1884; Fisher and Nitecki, 1982) from the Middle Ordovician of Quebec, Canada, in the general appearance of meroms and the shape of thallus, but differs from it in having a smaller corniculum and inflated proximal end of the merom shafts.

← **Figure 2.** *Fisherites coreanicus* Niko and Ikebe, sp. nov., from the Kangjinsan Formation (Middle Ordovician) of the Josen Supergroup, North Korea; holotype, KUJP 10201. 1, nuclear hemisphere, submerged in water. 2, nuclear vicinity of Figure 2-1, coated with ammonium chloride. 3, thin section parallel to merom shafts, central axis on right. All bar scales equal 1 cm.

Moreover, the interpositum-triangulum triplet causes a symmetrical intercalation, which is characteristic feature of the examined specimen, and rare in *F. occidentalis* on the contrary.

Fisherites reticulatus (Owen) of the Middle Ordovician Galena Group, North America (Finney and Nitecki, 1979; Fisher and Nitecki, 1982) is clearly distinguished from the present form in that *F. reticulatus* possesses a larger thallus than the *F. coreanicus* and lacks the interpositum-triaugulum triplet.

Fisherites burmensis Rietschel and Nitecki, 1984 of the Middle Ordovician in the Shan Plateau region, Burma differs from *F. coreanicus* in having the clustered intercalation.

Acknowledgments

We thank Drs. T. Kobayashi of the Japan Academy and T. Hamada of The University of Tokyo for fruitful discussions and critical reviews of the manuscript. Also we wish to thank Drs. K. Chinzei and D. Shimizu of Kyoto University for their permission to study the material in the collection in the Department of Geology and Mineralogy. Part of this research was supported by a grant from the Japan Academy.

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Pyongyang 平壌, Josen 朝鮮, Sangweon 祥原, Santao 三道, Liaoning 遼東, Fukuji 福地, Duwibong 斗囲峰, Yeongweol 寧越, Ogcheong 沃川, Chiangnan 長江, Hwangho 黄河, Samtung 三登, Syonglla 松羅, Imchyon 林村, Kotyongsan 高亭山, Sanbatsmol 麻田浦, Kangjinsan 江津山, Unhak 雲鶴, Mantal 晩達, Toufangkou 豆房溝, Machiakou 馬家溝.

平壌炭田地域，中部オルドビス系からの*Fisherites*（レセプタキュライテス類）：池辺が1936年に北朝鮮，朝鮮超層群より採集した中期オルドビス紀，レセプタキュライテス類の1個体は，その後，*Receptaculites coreanicus* Ikebe (nom. nud.) と予察的に命名された（池辺，1939)。今回の再検討の結果，比較的大型の葉状体（thallus)，および非対称挿入メロム（asymmetrical intercalary merom）を持つことから，この個体を，*Fisherites* 属に含めた．さらに *Fisherites coreanicus* Niko and Ikebe, sp. nov.としてその形質を記載した。　　児子修司・池辺展生

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 149, pp. 378–395, 9 Figs., April 30, 1988

853. SOME INOCERAMIDS (BIVALVIA) FROM THE CENOMANIAN (CRETACEOUS) OF JAPAN – III
THREE SPECIES OCCURRING COMMONLY IN THE NORTH-WEST PACIFIC REGION*

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Abstract. This is Part III of the serial descriptions of inoceramid species from the Cenomanian of Japan. In this part we describe the following three species which occur commonly not only in the Pacific areas of the USSR (Pergament, 1966) but also in Hokkaido. (1) *Inoceramus pennatulus* Pergament. As the specific name indicates, this species is characterized by a well developed posterior wing. For some reasons Pergament presented sufficient examples of the left valve but few of the right. This is supplemented by the specimens from Hokkaido. *I. pennatulus* occurs in both the Upper and Middle Cenomanian. (2) *I. reduncus* Pergament. Several examples of this species have been acquired from the Upper Cenomanian of Hokkaido. In addition, there are deficient specimens which are comparable with this species. If they are taken into consideration, the species may range down to the middle part of the Cenomanian. A question remains that *I. reduncus* Pergament, 1966 may be a junior synonym of *I. korjakensis* Terechova, 1965. (3) *I. ginterensis* Pergament. In addition to the original specimens from the Pacific areas of USSR, typical examples have been reported from the Upper Cenomanian of the Interior Province of the U.S.A. This species occurs also fairly commonly in the Middle to Upper Cenomanian of Hokkaido. Although there is some extent of variation, no marked distinctions have been noticed between examples of different provinces or stratigraphic positions.

Introduction

Succeeding to Part II, we continue to report the result of our study on inoceramid specimens of our collections from the Cenomanian rocks of Japan. In this paper (Part III), we describe the three species which have been already established by Pergament (1966) on plentiful material from the Pacific region of the USSR and occur also

*Received December 7, 1987; accepted March 3, 1988.

fairly commonly in Hokkaido.

The material of this study consists partly of the recent acquisitions by students of Waseda University during the field work conducted by Hirano in the Oyubari area, central Hokkaido. In addition to previous papers (Hirano *et al.*, 1981), the description in detail of the stratigraphy of this area is being under preparation for publication in which route maps and illustrated stratigraphic sections will be included (Hirano *et al.*, 1988).

Another part of the material is selected specimens obtained through the field works by members of the regional working group of the Cretaceous Stratigraphy and Mid-Cretaceous Events conducted by Matsumoto, with whom M. Noda, H. Hirano, K. Tanabe, H. Okada, Y. Miyata and S. Toshimitsu cooperated. The works were carried on the Oyubari, Ikushumbets, Obira (=Obirashibe) and northerly adjacent Kotanbetsu areas. As to the stratigraphic subdivisions and fossil locations, readers may refer to Matsumoto *et al.* (1978), Hirano *et al.* (1977), Matsumoto (1965), Tanabe *et al.* (1977) and Matsumoto and Okada (1973).

As another part of the material of this study some specimens of the older collections by Matsumoto are reexamined. They are from the celebrated Saku area in the transverse mid-valley of the River Teshio and also from the Shiyubari area, *i.e.*, northeasterly contiguous with the Oyubari area. The stratigraphy of these areas was described by Matsumoto (1942), in which fossil localities were tabulated and shown in route maps.

The locality numbers in this paper have the prefix R for the Obira and adjacent areas, the prefix T for the mid-valley of the River Teshio, the prefix Y for the Oyubari-Shiyubari area and the prefix Ik for the Ikushumbets area.

The repositories of the described specimens are as follows with abbreviation in parentheses:

Geological Collections, Kyushu University, Fukuoka (GK)

Jonan Geological Association, c/o M. Noda, Fukagochi, Oita (JG)

Paleontological Collections, School of Education, Waseda University, Tokyo (WE)

The technical terms for the morphologic characters and their abbreviations are the same as those used in Part I (Matsumoto and Noda, 1986, p. 410) and Part II (Matsumoto *et al.*, 1987).

Systematic Descriptions

Genus *Inoceramus* Sowerby, 1814

Inoceramus pennatulus Pergament, 1966

Figures 1-1, 2; 2-1, 2; 3

1966 *Inoceramus pennatulus* Pergament, p. 35, pl.5, figs. 1, 2; pl. 6, figs. 1,2; pl. 7, figs. 1–3.

Holotype:—No. 10-3580-33 (left valve) designated and illustrated by Pergament (1966, pl. 5, fig. 1), from the Mamechinsoko Group (Cenomanian) of northwestern Kamchatka.

Material:—GK. H89 (Fig. 1-1), internal mould of right valve, from a drift in a small gully between locs. T831 and T832 where the lower part of Member IIb is exposed, a small branch No. 2 of the River Teshio near Chirashinai (=Tirasinai in Matsumoto, 1942, pl. 12), Coll. T. Matsumoto. WE. P001Y (Fig. 1-2), internal mould of right valve, with test attached partially, from loc. Y250079, *i.e.* 170m southeast of loc. Y168 of Matsumoto (1942), on the right bank of the Hikage-zawa, Member My7 of the Shiyubari-Oyubari area, obtained by T. Sugiyama. JG. H2492 (Fig. 2-1), internal mould of left valve, with deficient postero-dorsal part, from loc. Ik1040 of Matsumoto (1965), Member IIc of the Mikasa Formation (Coll. M. Noda and T. Takahashi); JG. H2955 (Fig. 2-2), somewhat distorted left valve, from loc. R5400j5, Kanajiri-zawa, Member Mh of the Obira area (Coll. M. Noda, S. Toshimitsu and T. Matsumoto).

WE. P020Y (Fig. 3-A) and WE. P021Y (Fig. 3-B), left and right valves, with deficient apex of beak and incomplete ventral part, in one and the same nodule from loc. Y070161a84, Hakkin-zawa, middle part of Member My7, Oyubari area (Coll. A. Asai, Y. Tanaka and H. Hirano). They are to be called *Inoceramus* cf. *pennatulus*.

Description:—Shell normally large, inequivalve and inequilateral. Left valve more convex in the

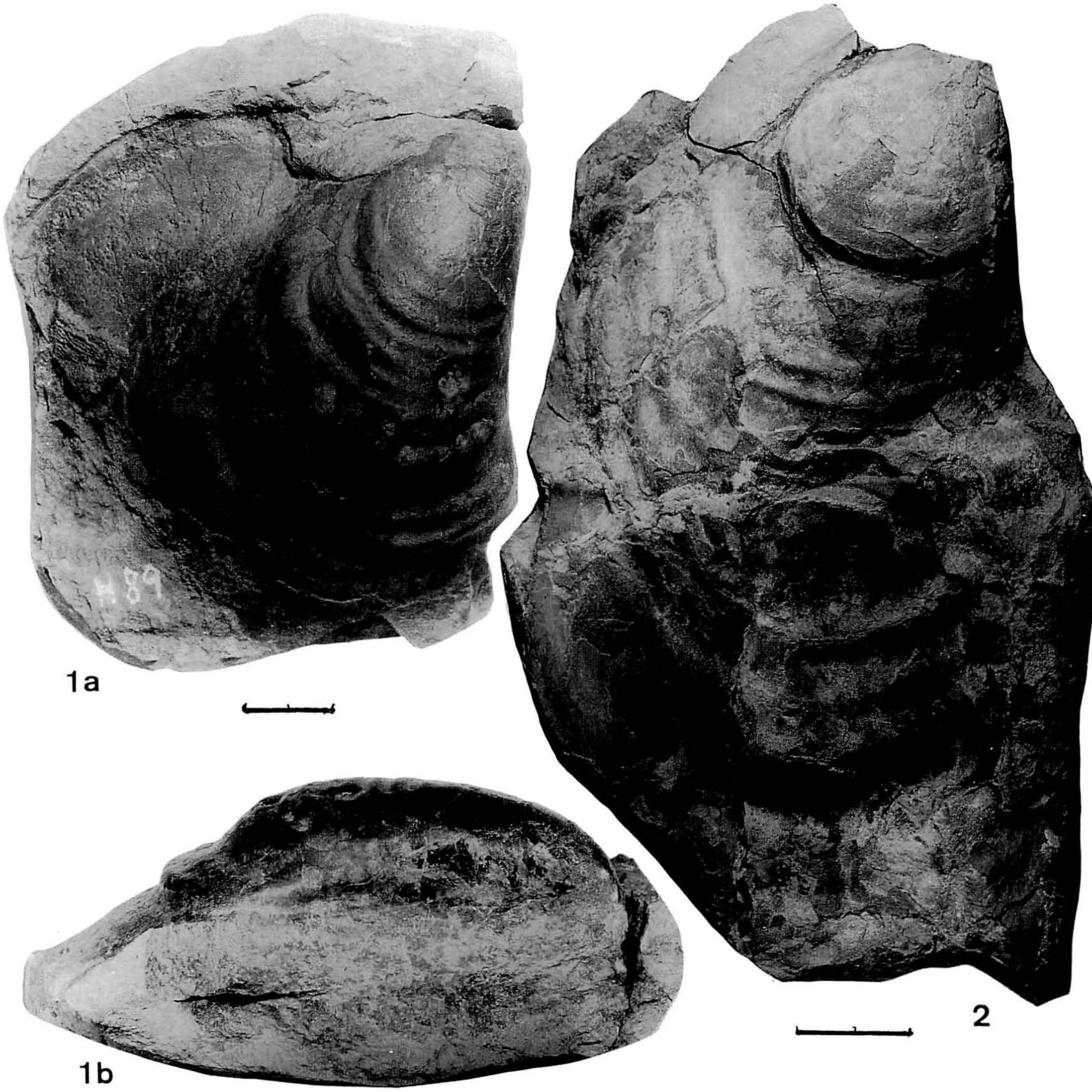


Figure 1. *Inoceramus pennatulus* Pergament.
1: GK. H89 (RV), drift in a gully between loc. T831 and T832, derived from Member IIb, Chirashinai, mid-valley of the Teshio (Coll. T. Matsumoto); lateral (a) and anterior (b) views. Scale bar = 20 mm. 2: WE. P001Y (RV), from loc. Y250079, Member My7, Hikage-zawa, Shiyubari-Oyubari area (Coll. T. Sugiyama); lateral view. Scale bar = 20 mm. M. Noda photos.

umbonal part than the right, with prominent umbo projecting over the hinge line and curved inward and forward. Anterior part steep and nearly vertical, abruptly falling down from the main part of the flank, which in turn inclines gradually to the broad and flat posterior wing. Hinge line long, being more than a half of the shell length. Axis of growth oblique and nearly straight or broadly arcuate (*i.e.* convex forward), forming an angle (δ) of 65° to 75° with the hinge line in late stages.

Surface of the shell ornamented with concentric subcostae and ribs of irregular strength and density. In the young stage ribs are weak,

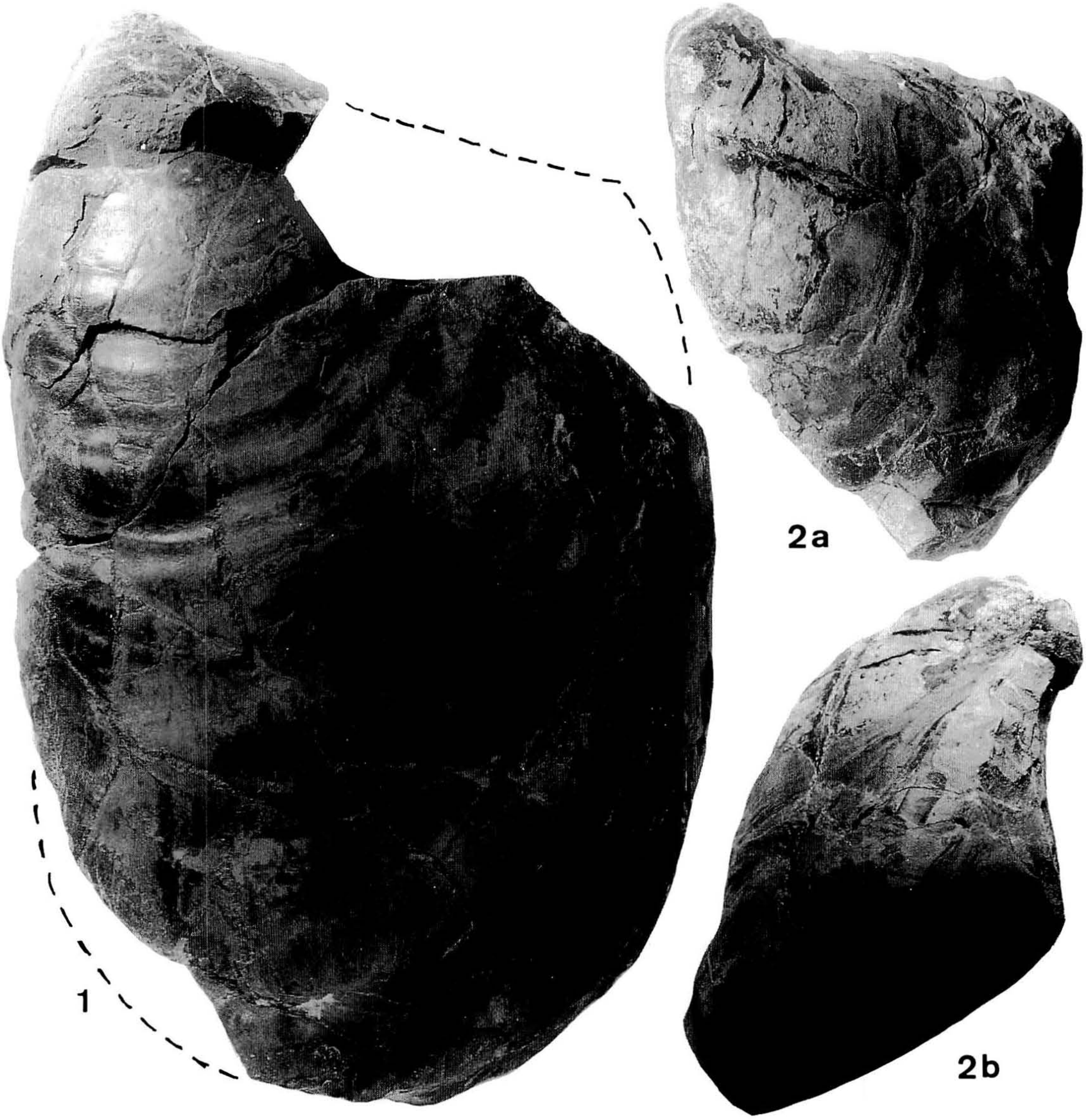


Figure 2. *Inoceramus pennatulus* Pergament.
1: JG. H2492 (LV) from loc. Ik1040, Member IIc of the Mikasa Formation, River Ikushumbets (Coll. M. Noda and T. Takahashi); lateral view, × 4/5. 2: JG. H2955 (LV) from loc. R5400j5, Kanajiri-zawa, Member Mh, Obira area (Coll. M. Noda, S. Toshimitsu and T. Matsumoto); lateral (a) and posterior (b) views, × 1. M. Noda photos.

but dense and fine lirae or rings may be well discernible. The subcostae and ribs are generally distinct in the middle growth-stage and lowered and weakened later. Irregularity may also occur in the course of the ribs, showing sometimes bifurcation, intercalation or disappearance. Flat posterior wing nearly smooth or with much weakened ribs. The ribs generally form an asymmetric curvature, being long and broadly arcuate posteriorly, more rounded ventrally and rather abruptly truncated by the nearly straight or broadly arcuate anterior margin.

Table 1. Measurements on selected specimens of *I. pennatulus*

Specimens	h	l	l/h	H	L	L/H	b	b/h	s	s/l	α	β	γ	δ
Holotype (L)*	110	67	.61	104	70	.67	—	—	~43	.64	~100°	~53°	~125°	~70°
GK. H89 (R)	137	101	.74	142	108	.76	48	.35	~55	.54	90°	—	135°	70°
WE. P001Y (R)	139	107	.77	141	109	.77	—	—	~52	.49	103°	—	~130°	~75°
JG. H2942 (L)	~165	~125	.76	184	127	.69	~43	.26	~80	.64	~91°	70°	—	~74°

* Measured on the photograph (Pergament, 1966, pl. 5, fig. 1) at the middle growth-stage. ~ Measurement on a restored outline.

Measurements:—See Table 1.

Comparison and discussion:—We have given above a free translation of diagnosis written in Russian by Pergament (1966, p. 35) and further supplemented it from our observation.

As the shell is large, the fossil specimens are often incomplete. This is true even for the types illustrated by Pergament. Of his nine specimens, eight are more or less incomplete left valves and a single right valve which is deficient for lack of the ventral half. This is supplemented by our better preserved specimens, although they are by no means complete.

Noda and Matsumoto (1976) once interpreted this species too much broadly. We now define this species strictly, regarding "*I. pennatulus interjectus*" Pergament (1966, p. 37, pl. 8, fig. 1; pl. 9, figs. 1–3) as distinct from *I. pennatulus,*

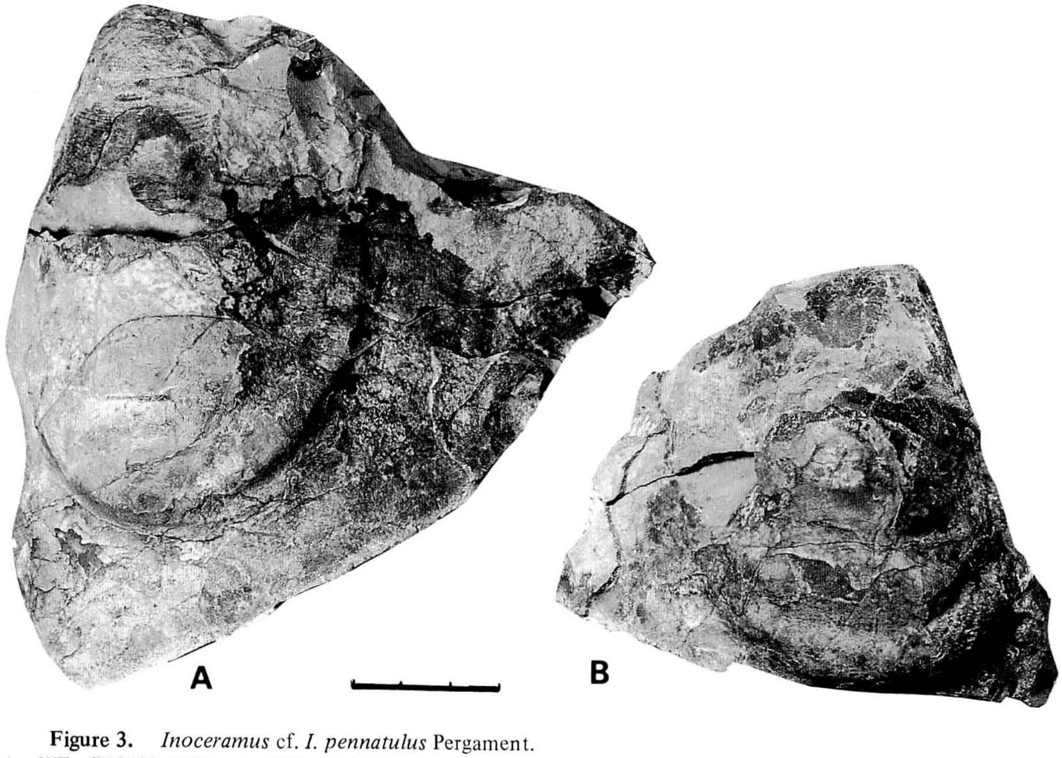


Figure 3. *Inoceramus* cf. *I. pennatulus* Pergament.
A: WE. P020Y (LV); B: WE. P021Y (RV). Both in one and the same nodule from loc. Y070161a84, Hakkin-zawa, Member My7, Oyubari area (Coll. Y. Tanaka, H. Hirano and A. Asai); lateral view, x 2/3. Scale bar = 30mm.

A. Asai photos.

because the posterior wing is narrow in *I. interjectus* and the axis of growth is more oblique, with narrower angle of inclination than that of *I. pennatulus*. The two specimens which were illustrated as examples of *I. pennatulus* by Noda and Matsumoto (1976, Cr–31, figs. 4, 5) should be revised to *I. interjectus*. Sornay (1978, p. 508) has already remarked that "*I. pennatulus interjectus*" is closely allied to *I. conicus* Gueranger (see Sornay, 1978, pl. 1, figs. 1–3). This implies that *I. interjectus* is independent of *I. pennatulus*.

Occurrence:–Loc. Y250079, Hikage-zawa, Oyubari area, Member My7 by Hirano *et al.* (1988); this locality is 170m southeast of loc. Y168, lower part of Member Mf by Matsumoto (1942). From near locs. T831 and T832 at Chirashinai, 4km southeast of Saku, in the transverse mid-valley of the River Teshio, lower part of Member IIb by Matsumoto (1942). These two localities are in rather lower part of the Cenomanian but may be referred to the lower Middle Cenomanian on the international scale. Loc. Y070161a84 of the Hakkin-zawa (Oyubari area), where examples of *I.* cf. *pennatulus* were obtained, is assigned to the middle part of Member My7, Middle Cenomanian, because of the occurrence of *Acanthoceras takahashii* Matsumoto from the nearby locality (Y070163b83). In all the above cases the host rock is dark grey mudstone or sandy siltstone.

Loc. Ik1040 on the River Ikushumbets, 470m downstream from the Katsura-zawa Dam, Member IIc, *i.e.* middle part of the Mikasa Formation; loc. R5400j5, Kanajiri-zawa, Member Mh of the Obira area. These two localities are evidently ascribed to the Upper Cenomanian. The host rock is again dark grey mudstone.

Inoceramus reduncus Pergament, 1966

Figures 4; 5-2–4; 6

1966 *Inoceramus reduncus* Pergament, p. 40, pl. 16, figs. 1, 2; pl. 17, figs. 1, 2; pl. 18, figs. 1–3.
1966 *Inoceramus reduncus* Pergament subsp. nov. ?, p. 42, pl. 19, figs. 1, 3.

Holotype:–No. 9-3580-54, designated and illustrated by Pergament (1966, p. 40, pl. 16, fig. 1), from the Ginterobskaya Group (Cenomanian) of the Ugolnaya Bay area in the northeastern part of the Koryak Mountains.

Material:–GK. H25 (Figs. 4A–C), somewhat displaced both valves, *i.e.* internal mould of left valve, with shell attached partially, and internal and external moulds of right valve with inner and outer shell layers attached respectively, from loc. T7b, Rubeshibe-zawa, upper part of Member IIb of the Abeshinai-Saku area (Matsumoto, 1942), Coll. T. Matsumoto; GK. H10146 (Fig. 5-2), right valve and partly cropping out left valve, with shell preserved for the major part, from loc. R5243, right side of the River Obirashibe, Member Mh of the Obira area (Tanabe *et al.*, 1977), Coll. T. Matsumoto; GK. H10147 (Fig. 5-3), left valve with shell layer and hinge plate preserved partly but lacking in posterior part, from loc. R5407c, Kanajiri-zawa, Member Mh of the Obira area (*Ditto*, 1977), Coll. T. Matsumoto; JG. H2960 (Figs. 6A, B), internal mould of left valve, with shell preserved partly, from loc. R5400T, Kanajiri-zawa, Member Mh of the Obira area (*Ditto*, 1977), Coll. M. Noda, S. Toshimitsu and T. Matsumoto.

GK. H8267 (Fig. 5-4), umbonal part of left valve, partly composite, internal mould, from loc. R100 on Highway 239, between Soeushinai and Kotanbetsu, 800m west of the Kiritachi Pass, Member My5 of Hashimoto *et al.* (1965), Coll. T. Matsumoto and H. Okada. This is *I.* cf. *reduncus* (see discussion below).

Description:–Shell medium-sized normally, but occasionally large, inequilateral and highly inequivalve. Left valve inflated, with much convex and prominent umbonal part and markedly incurved beak, as the specific name tells. The convex curvature of the left valve profile along the axis of growth changes at the beginning of the middle stage where concentric constriction occurs normally; another constriction may occur later. Right valve less inflated than the left and the change of convexity on the profile along the axis of growth may be expressed weakly by the concentric constriction or deeper interspace of ribs at the position

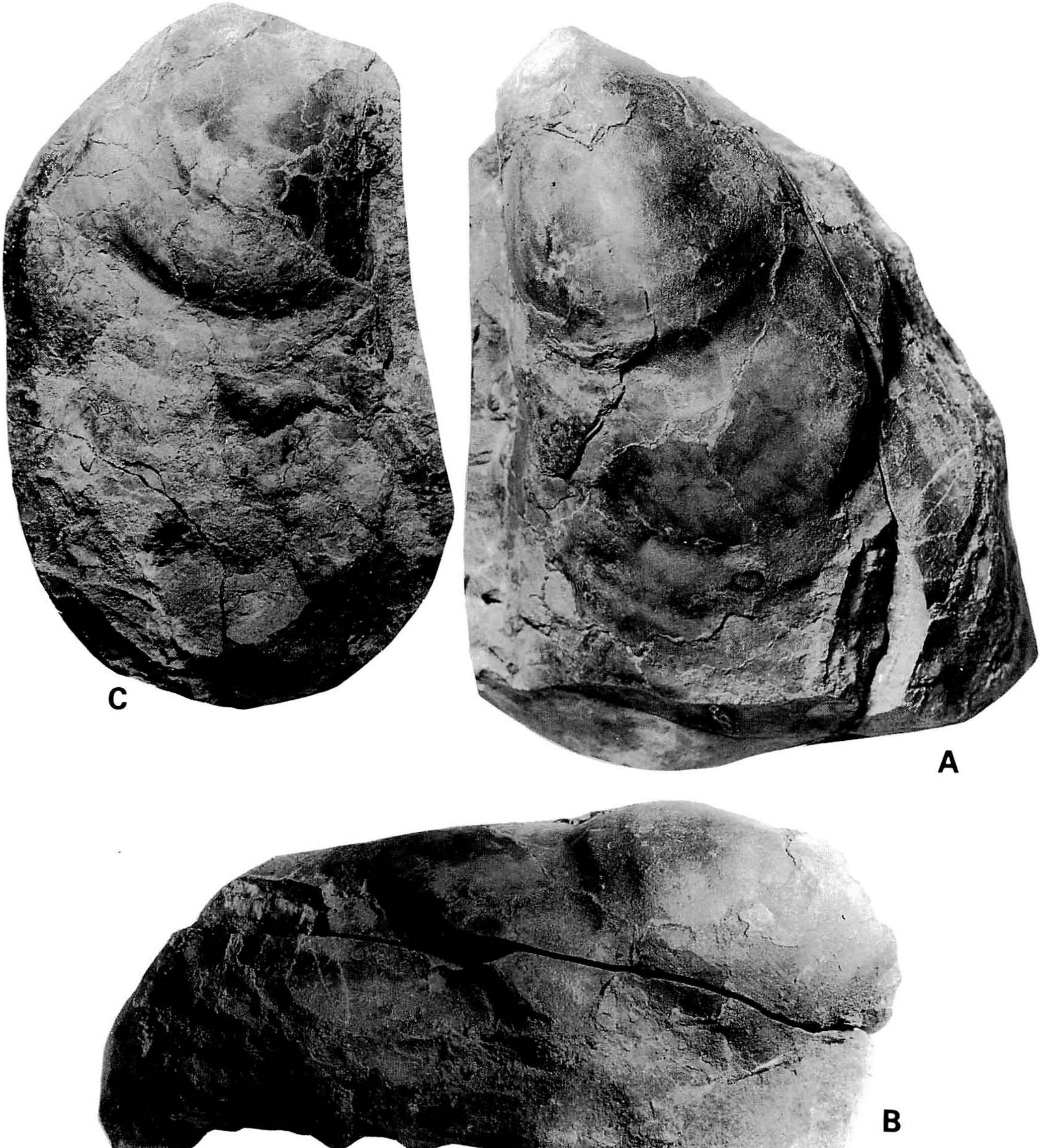


Figure 4. *Inoceramus reduncus* Pergament.
A–C: GK. H25 (BV) from loc. T7b, Rubeshibe-zawa, upper part of Member IIb, Abeshinai-Saku area (Coll. T. Matsumoto); lateral (A) and posterior (B) views of LV; lateral view of RV (C), × 1. M. Noda photos.

corresponding to that of the left valve. Anterior side abruptly bent from the disk and nearly perpendicular to the plane of the valves, with slightly concave anterodorsal part. Posterior wing-like area narrow and not clearly defined, for it passes gradually from the convex main part of disk.

Outline of shell roughly asymmetric-triangular dorsally and broadly subrounded ventrally. H somewhat but not much larger than L, with L/H about 0.7 in LV and 0.8 in RV on the average. Anterior margin roughly straight, with slight anterodorsal concavity and anteroventral gentle convexity; ventral margin more or less broadly rounded, passing to gently convex to nearly straight posterior margin. Hinge line of moderate length. Anterior hinge angle (α) nearly 90° in the typical form but may be somewhat larger in others. Posterior hinge angle (γ) obtuse and may vary with growth or between individuals.

Shell of early growth-stage up to the first constriction nearly smooth or with faint concentric undulations; but dense and fine concentric lines on the surface of outer shell layer or corresponding rings on that of inner shell layer may be well discernible. In the middle and late growth-stages ribs and subcostae develop distinctly, being somewhat irregular in strength and density. Minor concentric rings may be combined with them when preservation is favourable. Concentric constrictions or deeper interspaces occur at periodic intervals, as mentioned above. In the gerontic stage the ornament may weaken.

Measurements:–See Table 2.

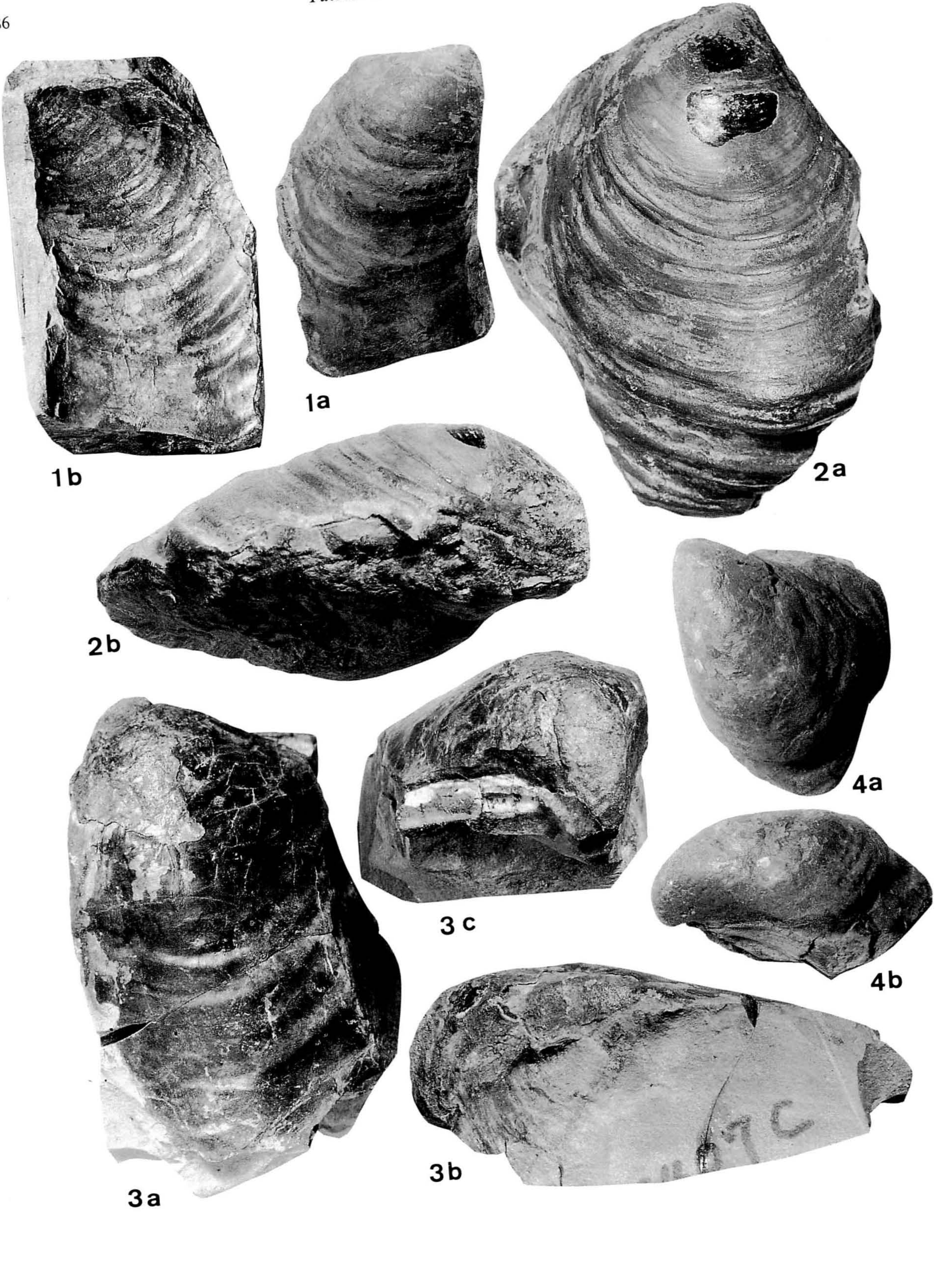
Comparison and discussion:–The specimen briefly described and illustrated under *Inoceramus koriakensis* Terechova (in Verechagin *et al.*, 1965, p. 36, pl. 23, fig. 1), which was acquired from the Ginterobaskaya Group in the area of the Ugoinaya Bay, looks very similar to the holotype and other typical examples of this species. Therefore, we would suggest that *I. reduncus* Pergament, 1966 could be a junior synonym of *I. korjakensis* Terechova, 1965. As we have not studied the actual specimens themselves in USSR and as Pergament (1966) described *I. reduncus* on many specimens with fine illustrations, we use in this paper the specific name *I. reduncus* provisionally. We expect that a palaeontologist in the USSR would give a definite answer to our question.

The left valve of GK. H25 (Figs. 4A, B) is essentially similar to that of a paratype illustrated by Pergament (1966, pl. 18, fig. 1) and the right valve of GK. H25 (Fig. 4C), if its deficient beak is adequately restored, resembles that of another paratype (Pergament, 1966, pl. 16, fig. 2). A small specimen, GK. H8267 (Figs. 5-4a, b) is probably the inflated umbonal part, showing a constriction at the beginning of the middle aged part; its later part must have been destroyed away. It is comparable with the one illustrated by Pergament (1966, pl. 18, fig. 2a). GK. H10147 (Fig. 5-3), secondarily compressed left valve with apparently broad disk in younger half, resembles again the one figured by Pergament (1966, pl. 17, fig. 2). The ligamental structure of the hinge plate is observable in the two specimens, but the conjugated right valve is not preserved in ours.

The right valve of GK. H10146 (Fig. 5-2) is quite similar to the form represented by two specimens of Pergament (1966, pl. 19, figs. 1, 3). The latter was regarded with a query as an unnamed subspecies of *I. reduncus* by Pergament on account of some difference in the ontogenetic change of L/H, but we do not think the difference so significant as deserving subspecific separation. Our example occurs in the same Member Mh of the Obira area as the typical form. Therefore, it is regarded as showing a

Table 2. Measurements on selected specimens of *I. reduncus*

Specimens	h	l	l/h	H	L	L/H	b	b/h	s	s/l	α	β	γ	δ
Holotype (L)	75	55	.73	~91	~63	.69	22	.29	—	—	—	~70°	—	—
(R)	58	50	.86	~71	~53	.75	—	—	36	.68	93°	—	135°	45°
GK. H25 (L)	~90	78	.87	98	~68	.70	33	.37	~46	.59	—	~50°	135°	45°
GK. H10146 (R)	73	60	.82	75	63	.84	25	.33	36	.60	98°	—	148°	50-70°
JG. H2960 (L)	60	62	1.03	68	61	.89	18	.26	34	.56	94°	89°	159°	63°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1b
2a
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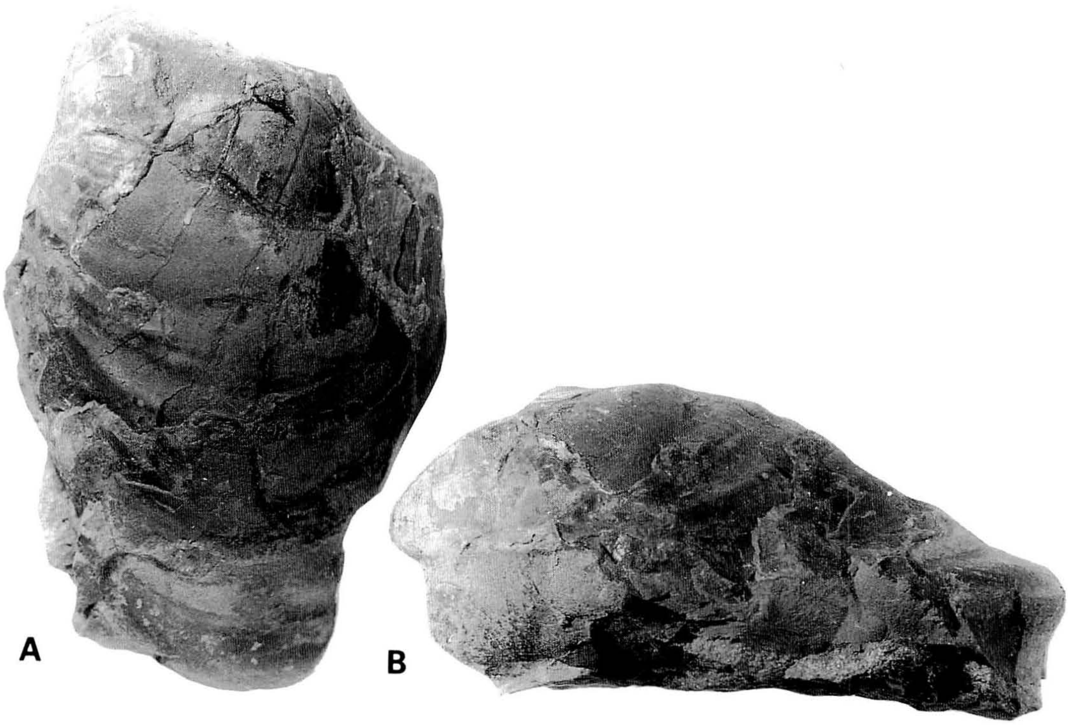

Figure 6. *Inoceramus reduncus* Pergament.
JG. H2960 (LV) from loc. R5400T, Kanajiri-zawa, Member Mh, Obira area (Coll. M. Noda, S. Toshimitsu and T. Matsumoto); lateral (A) and anterior (B) views, x 1. M. Noda photos.

variation within this species. Incidentally the left valve of GK. H10146 is somewhat displaced toward the venter, with beak concealed in the rock matrix (see Fig. 5-2b).

The affinity of *I. reduncus* with *I. gradilis* Pergament (see Matsumoto *et al.*, 1987, p. 155) should be considered. The latter may be a specialized offshoot from the former or the two species may have been derived from a common ancestor. We presume that their origin could be thought in such species as *I. tenuis* Mantell and eventually in *Birostrina concentrica* (Parkinson) on the ground of change in morphologic characters and also stratigraphic occurrence.

Occurrence:—The representative specimens described above are from loc. T7b, Rubeshibe-zawa, upper part of Member IIb of the Abeshinai-Saku area (Matsumoto, 1942); locs. R5243, R5400T and R5407c, all in Member Mh of the Obira area (Tanaka, 1963; Tanabe *et al.*,

← **Figure 5.** *Inoceramus ginterensis* Pergament (1) and *Inoceramus reduncus* Pergament (2–4).
1: GK. H8260 (RV) from loc. R5408, Kanajiri-zawa, Member Mh, Obira area (Coll. T. Matsumoto). Internal (a) and external (b) moulds, x 1. 2: GK. H10146 (RV) from loc. R5243, the River Obirashibe, Member Mh, Obira area (Coll. T. Matsumoto); lateral (a) and anterior (b) views, x 1. A portion of LV shown on the basal surface of 2b. 3: GK. H10147 (LV) from loc. R5407c, Kanajiri-zawa, Member Mh, Obira area (Coll. T. Matsumoto); lateral (a), anterior (b) and dorsal (c) views, x 1. 4: GK. H8267 (young part of LV) from loc. R100, 800 m west of the Kiritachi Pass on Highway 239 between Soeushinai and Kotanbetsu (Coll. T. Matsumoto and H. Okada); lateral (a) and anterior (b) views, x 1. It is better to call this *I.* cf. *reduncus*. M. Noda photos.

1977). These are in the Teshio Mountains of northwestern Hokkaido and referred to the upper part of the Cenomanian. A comparable specimen is from loc. R100 on Highway 239 across the Teshio Mountains between Soeushinai and Kotanbetsu, Member My5 of Hashimoto *et al.* (1965), which is referred to the upper part of the Middle Cenomanian.

Inoceramus ginterensis Pergament, 1966

Figure 5-1; 7-1–4; 8-1–5; 9

1966 *Inoceramus ginterensis* Pergament, p. 50, pl. 27, figs. 1, 2; pl. 28, figs. 1, 2; pl. 29, fig. 1.
1977 *Inoceramus ginterensis* Pergament; Cobban, p. 15, pl. 19, fig. 3.
1977 *Inoceramus ginterensis* Pergament; Kauffman and Powell, p. 64, pl. 3, figs. 1–4, 6; pl. 4, figs. 1,3–6; pl. 5, figs. 2, 3, 5; pl. 7, fig. 4.
1983 *Inoceramus ginterensis* Pergament; Cobban, p. 5, pl. 2, figs. 17, 18.

Holotype:—No. 16p-3580-87, designated and figured by Pergament (1966, p. 50, pl. 27, fig. 1) (copied by Kauffman and Powell, 1977, pl. 4, fig. 4), from the Cenomanian in the Ugoinaya Bay area in the northeastern part of the Koryak Mountains.

Material:—GK. H28A (BV) (Figs. 7-4a–c), B (LV of BV) (Fig. 7-3) and C (LV) (Figs. 7-2a–b), internal moulds with inner shell layer adhering to considerable parts; also fragmentary pieces of external moulds, with outer shell layer adhering, from loc. T843, the Chirashinai, a small tributary to the middle course of the River Teshio, unit IIb-c (β) of Matsumoto (1942, p. 189), Coll. T. Matsumoto; GK. H417A (RV) (Fig. 8-5) and B (LV), internal moulds and part of external mould with shell adhering, from loc. Y508, the Tengu-zawa, Member IIm (Matsumoto, 1942, p. 230), Shiyubari-Oyubari area, Coll. T. Matsumoto; GK. H8260A (RV) (Fig. 5-1a), internal mould with inner shell layer adhering, and GK. H8260B (Fig. 5-1b), external mould of A, with outer shell layer adhering, from loc. R5408, Kanajiri-zawa, Member Mh of the Obira area (Tanabe *et al.,* 1977, fig. 7), Coll. T. Matsumoto.

WE. P002Y (LV) (Fig. 7-1), composite internal mould from loc. Y070135m82, lower part of Member My7, Coll. H. Hirano, N. Kato and Y. Nakanishi; WE. P037Y (RV) (Fig. 8-1), internal mould, with uncleaned shell adhering on the umbonal part, from loc. Y070135f'82, lower part of Member My7, Coll. H. Hirano and Y. Nakanishi; WE. P023Y (Fig. 8-4), large but deficient LV, with shell adhering for major part, from loc. Y070135k84, lower part of Member My7, Coll. A. Asai; WE. P024Y (PV) (Fig. 8-2), internal mould from loc. Y070137e83, lower part of Member My7, Coll. A. Takagi and H. Sekine; WE. P022Y (RV) (Fig. 8-3), composite internal mould from loc. Y070119, upper part of Member My7, Coll. H. Ando; WE. P040Y (Fig. 9), large right valve from loc. Y070137j83, Member My7, Coll. A. Takagi and H. Sekine; all on the routes (stream and forestry roads) along the Hakkin-zawa, Oyubari area. It may be better to call the last one *I.* aff. *I. ginterensis* (see discussion below).

Description:—Shell normally medium-sized and weakly inequivalve; the left valve somewhat, but not much, more convex and slightly higher than the right, with its beak slightly projecting over hinge line.

Outline of shell subovate to subrectangular, fairly higher than long, axis of growth forming angle (δ) of 60° to 65° with the hinge line; anterior margin nearly straight, ventral margin asymmetrically and moderately rounded, passing to broadly arcuate (convexly) posterior margin, which forms an obtuse angle (γ) of about 135° with the fairly long hinge line.

Valves gently inflated, with the maximum convexity somewhat ventrally from the umbonal part, passing gradually to the flat, postero-dorsal wing-like part. Anterior side steep, abruptly bent from the disk and may be somewhat concave near the umbonal part.

Shell in the early growth-stage ornamented with faint concentric undulations and fine and dense concentric rings or lirae which may be discernible under favourable condition of preservation. In the middle to late growth-stages concentric ribs and subcostae develop with

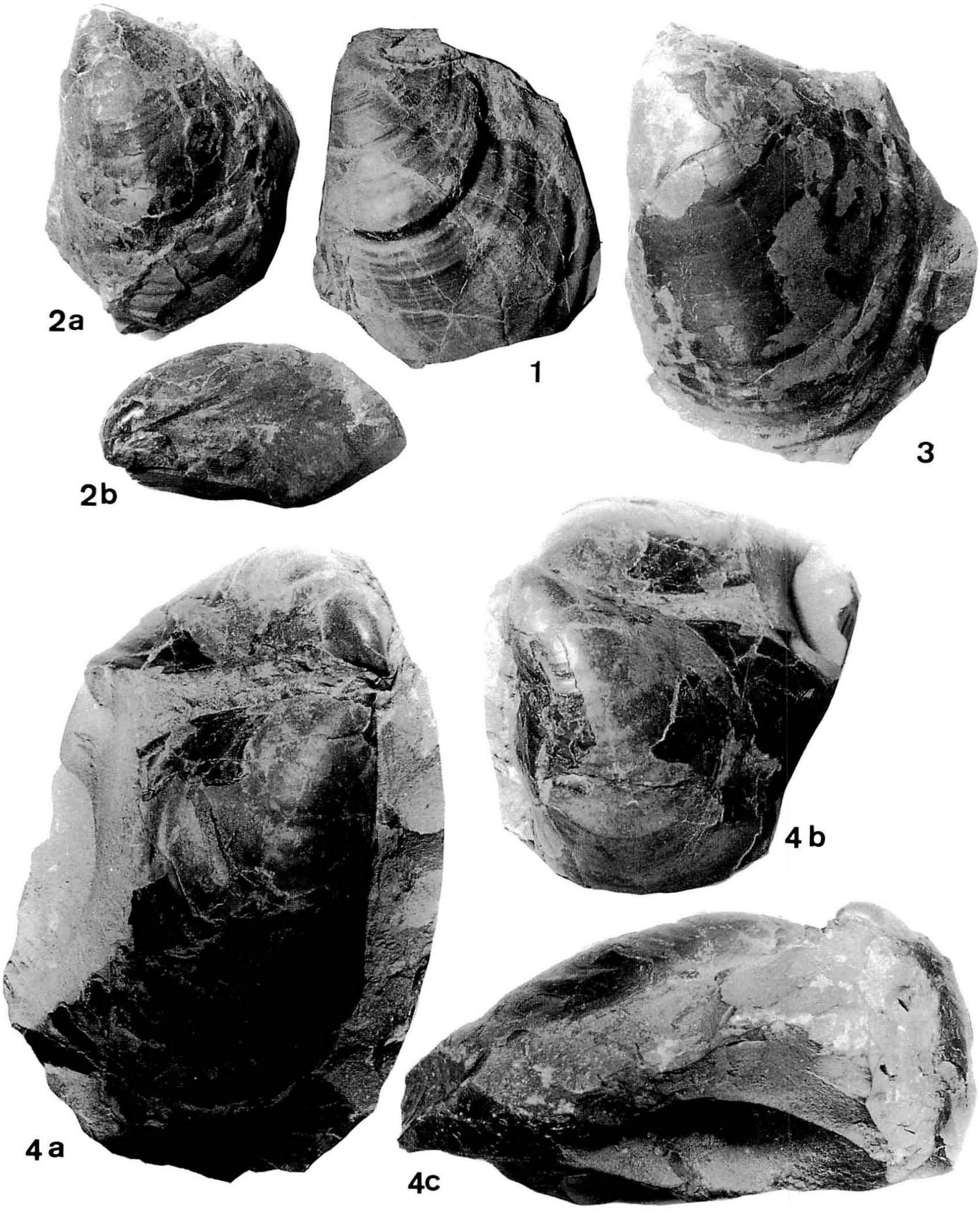

Figure 7. *Inoceramus ginterensis* Pergament.
1: WE. P002Y (LV), from loc. Y070135m82, Hakkin-zawa, lower part of Member My7, Oyubari area (Coll. H. Hirano, N. Kato and Y. Nakanishi). A. Asai photo. 2: GK. H28C (LV), lateral (a) and anterior (b) views, × 1; 3: GK. H28B (LV), lateral view, × 1; 4: GK. H28A (BV), right (a) and left (b) lateral and anterior (c) views, × 1. The above three (2–4) in one and the same nodule from mudstone at loc. T843, Chirashinai, Member IIb-c (β facies), mid-valley of the Teshio (Coll. T. Matsumoto). M. Noda photos.

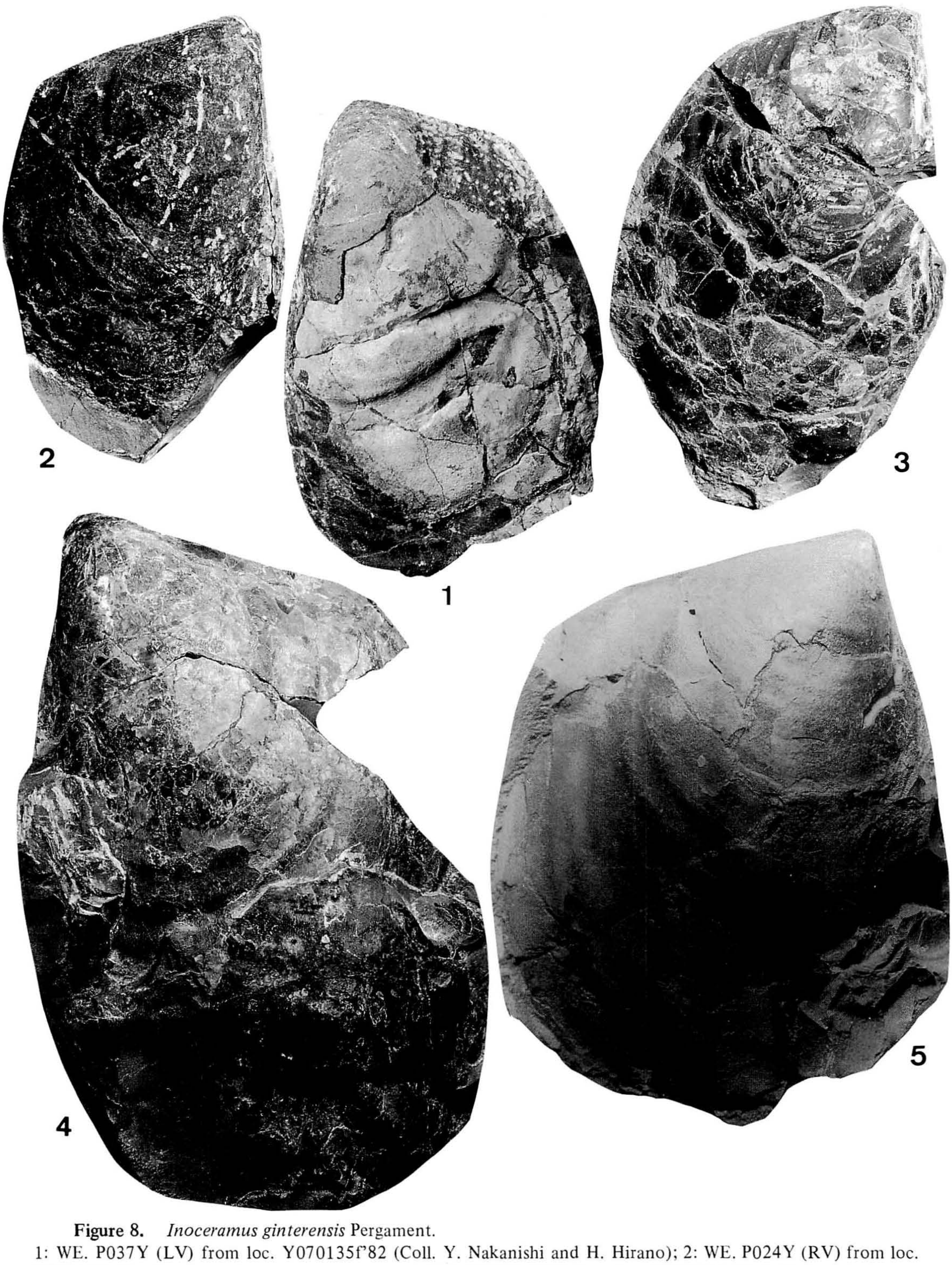

Figure 8. *Inoceramus ginterensis* Pergament.
1: WE. P037Y (LV) from loc. Y070135f'82 (Coll. Y. Nakanishi and H. Hirano); 2: WE. P024Y (RV) from loc. Y070137e83 (Coll. A. Takagi and H. Sekine); 3: WE. P022Y (RV) from loc. Y070119 (Coll. H. Ando); 4: WE. P023Y (LV) from loc. Y070135k84 (Coll. A. Asai). These four (1–4) on the Hakkin-zawa route, Member My7 (1, 2, 4 lower part; 3 upper part), Oyubari area, × 2/3. A. Asai photos. 5: GK. H417A (RV) from loc. Y508, Tengu-zawa, Member IIm of the Shiyubari-Oyubari area (Coll. T. Matsumoto), × 1. M. Noda photo.

Table 3. Measurements on selected specimens of *I. ginterensis*

Specimens	h	l	l/h	H	L	L/H	b	b/h	s	s/l	α	β	γ	δ
Holotype (L)	81	60	.74	86	~58	.67	23	.28	~36	.60	93°	67°	138°	61°
GK. H28A (L)	48	36	.75	54	~38	.70	17	.35	26	.72	86°	53°	130°	57°
(R)	50	36	.72	57	40	.70	12	.24	26	.72	86°	—	130°	57°
GK. H28B (L)	56	44	.79	60	45	.75	15	.27	30	.68	~85°	—	138°	60°
GK. H417A(R)	90	73	.81	98	~67	.68	~21	.23	~52	.76	96°	—	138°	60°
WE. P002Y(L)	50	38	.76	52	36	.69	~14	.28	~28	.78	~83°	—	135°	56°
WE. P022Y(R)	135	93	.69	140	~100	.71	—	—	~56	.60	93°	—	~128°	65°
WE. P023Y(L)	120	88	.73	132	96	.73	~30	.25	~68	.77	85°	65°	115°	60°
WE. P024Y(R)	86	66	.77	97	74	.76	19	.22	~50	.76	85°	—	135°	60°

irregular intensity and density, showing sometimes bifurcation or intercalation; interspaces may be occasionally deep; fine concentric lines or rings may be discernible where shell is favourably preserved.

Measurements:–See Table 3.

Comparison and discussion:–In addition to Pergament (1966), Kauffman and Powell (1977) described at full length the diagnostic characters of this species and gave remarks on its relationships with other species. The specimens from Oklahoma, figured by Kauffman and Powell (1977), are mostly typical examples, except for a small specimen (*Ditto*, pl. 1, fig. 2) which shows "abnormally close, regular juvenile rugae." Cobban (1977, 1983) also reported the occurrence of this species in other areas of the Interior Province.

The specimens from Hokkaido figured in this paper are also typical, although there may be slight or unimportant differences which can be interpreted as being within the extent of variation or modification caused by the mode of preservation.

On the ground of above observations we can state that no significant distinctions have been noticed between populations of such separate provinces as the Koryak-Kamchatka belt and S. Sakhalin-Hokkaido or the Northwest Pacific and the Interior Province of North America. Should this be warranted, *I. ginterensis* would be found more extensively. A probable example from Madagascar (=*I. flavas* Sornay, 1965, pl. A, fig. 1 *non* fig. 2) as pointed out by Kauffman and Powell (1977, p. 66) could be evaluated on this account.

WE. P022Y (Fig. 8-3) from the upper part of Member My7 of the Oyubari area is quite similar to WE. P024Y (Fig. 8-2) from the lower part of the same member. This may suggest that there is no marked distinction between the forms from different stratigraphic positions. Member My7 of Hirano *et al.*, (1988) is mainly referred to Middle Cenomanian, because *Turrilites acutus* Passy and *Acanthoceras takahashii* Matsumoto occur in the middle part of the member. Although the scheme of stratigraphic division of Matsumoto (1942) is not the same as that of Hirano *et al.* (1988), GK. H417 is from Member IIm of the Shiyubari area by Matsumoto (1942), which is the uppermost unit of the Cenomanian sequence, and GK. H28A–C came also from the upper part of the Cenomanian in the Teshio Mountains. There is, however, no significant difference between the GK specimens from the upper part of the Cenomanian and the WE specimens from the middle part of the same stage.

The above may be a tentative result from better preserved specimens at our disposal. It would be desirable to examine the subject on population samples of enough number. In this paper we exclude atypical or doubtful specimens described under *I. ginterensis* by Pergament (1966, pl. 25, fig. 5; pl. 26, fig. 1; pl. 30, fig. 1) and also *I.* aff. *ginterensis* of Pergament (1966, p. 52, pl. 32, fig. 2; pl. 33, figs. 2, 3; pl. 34, figs. 1,

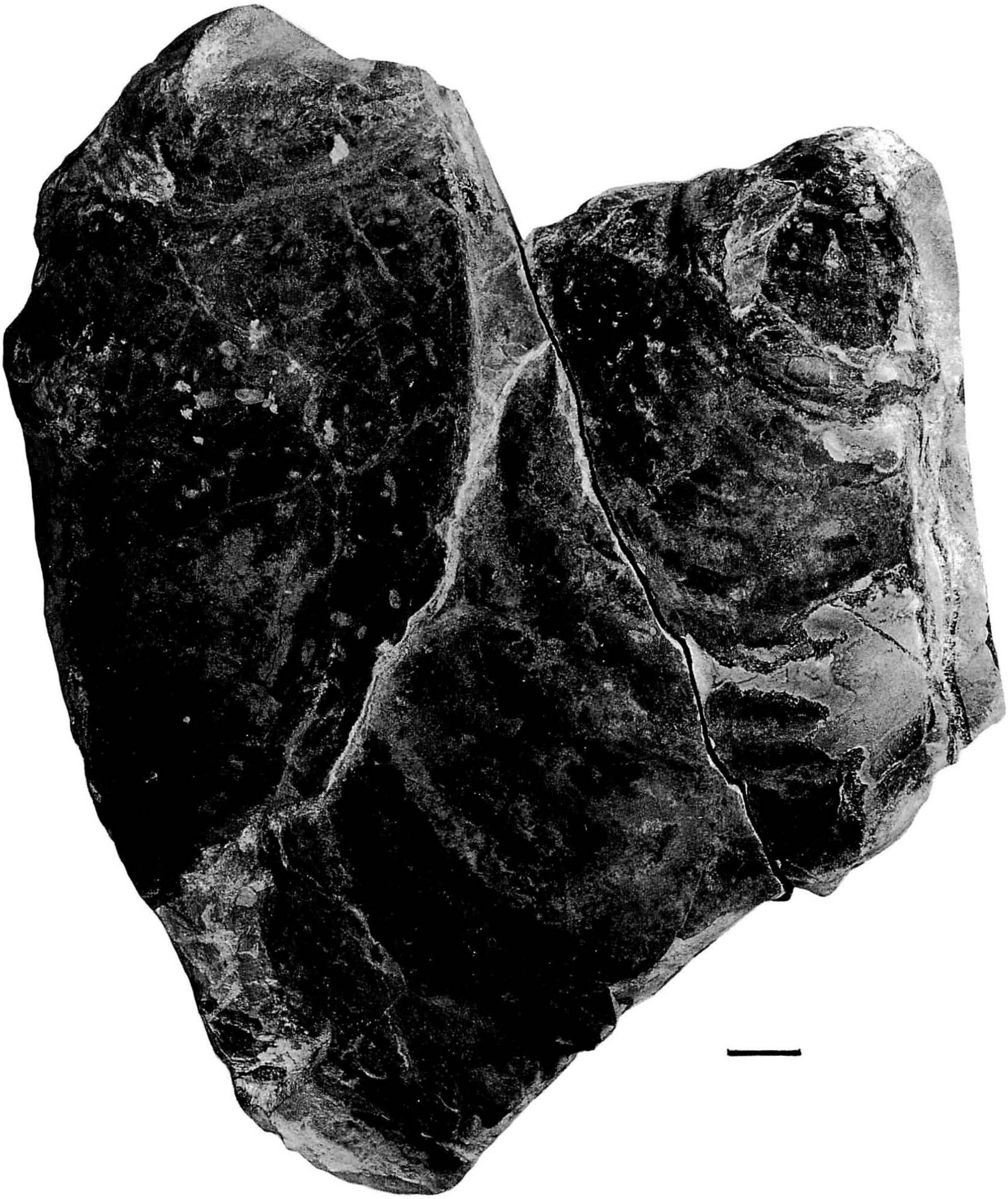

Figure 9. *Inoceramus* aff. *I. ginterensis* Pergament.
WE. P040Y (RV) from loc. Y070137j83, Hakkin-zawa, Member My7, Oyubari area (Coll. A. Takagi and H. Sekine), x 1. Scale bar = 10mm. A. Asai photos.

2) from *I. ginterensis* in our proper sense. Likewise there are several doubtful specimens in our collection which deviate from the typical form of *I. ginterensis*. WE. P040Y (Fig. 9) may be an example of them, since it resembles the one illustrated by Pergament (1966, pl. 34, fig.

2) under *I.* aff. *ginterensis.* How they should be treated and what they mean remain unsettled. They need further study on sufficient material.

As to the phylogenic origin of *I. ginterensis* we recall such a species as *I. takahashii* Matsumoto et Noda (1986, p. 414, pl. 84, fig. 1), from the Lower Cenomanian of Hokkaido, in the subrectangular outline, weakly inequivalve state, less inflated valves and irregular ribbing. *I. ginterensis* is more oblique, with more rounded ventral margin and has stronger major ribs in the middle to late growth-stages in addition to the weaker subcostae.

I. heinzi Sornay (1965, p. 7, pl. B, fig. 4) (also Matsumoto and Noda, 1986, p. 415, pl. 83, fig. 4; pl. 85, figs. 2, 3), from near the Cenomanian-Turonian boundary, is somewhat allied to *I. ginterensis* but has more projected and more strongly incurved left umbo, shorter hinge line and more oblique axis of growth.

Occurrence:—The described specimens of the typical form are from (1) loc. T843 in the upper reaches of the Chirashinai, a tributary to the middle course of the River Teshio, mudstone in the lower part of Unit IIb–c (β) of Matsumoto (1942), upper part of the Cenomanian, Abeshinai-Saku area, Teshio Mountains; (2) loc. Y508, above the first water-fall of the Tengu-zawa, mudstone of Member IIm of Matsumoto (1942), upper part of the Cenomanian, Shiyubari-Oyubari area; (3) loc. R5408, Kanajiri-zawa, mudstone of Member Mh of Tanaka (1963), upper part of the Cenomanian of the Obira area; (4) locs. Y070135 and Y070137, mudstone in the lower part of Member My7 of Hirano *et al.* (1988), Hakkin-zawa, Middle Cenomanian; (5) loc. Y070119, mudstone in the upper part of Member My7, Hakkin-zawa, Oyubari area.

Summary

As a summary the species described in this paper are listed below with indication of their known age and area in Hokkaido.

I. pennatulus Pergament: Upper Cenomanian of the Ikushumbets and Obira areas; comparatively lower part of the Cenomanian in the Oyubari and Saku areas, which may be lower Middle Cenomanian on the international scale.

I. reduncus Pergament: Upper Cenomanian of the Saku and Obira areas; comparable form (*I.* cf. *reduncus*) in the upper Middle Cenomanian of the Kotanbetsu area.

I. ginterensis Pergament: Upper Cenomanian of the Saku, Obira and Shiyubari areas; also Middle Cenomanian of the Oyubari area.

To sum up, the three species show fairly long ranges in stratigraphic occurrence. This is similar to, if not quite identical with, the situation in the Pacific region of the USSR (Pergament, 1966, figs. 4, 6, 8, 10; 1977, p. 91; 1981, table 5). The Zone of *I. pennatulus* in the Upper Cenomanian of Japan (Matsumoto, 1977) is merely a local zone in the Ikushumbets area. The same named zone is set in the middle part of the Cenomanian by Pergament, but *I. pennatulus* occurs also in the upper part of the stage in the Pacific USSR.

Acknowledgements

We are much indebted to many persons who worked with us or with one of us in the stratigraphic investigations of the Saku, Kotanbetsu, Obira, Ikushumbets and Shiyubari-Oyubari areas, where inoceramids were collected along with other fossils. Their names are recorded in the item *Material* of the descriptions of species as well as in the *Introduction.*

Thanks are also due to the authorities of the Forestry Bureau Branch Offices of the respective districts for permission and help to us to do geological field works in the areas of their care.

Hirano received financial support of the Grant-in-Aid for Individual Research of the Ministry of Education, Science and Culture (C, No. 57540464 for 1982 and No. 61540577 for 1986 and 1987), Research Fund of the Geographical Society of Tokyo for 1983 and 1987 and Grant-in-Aid for Fundamental Science Research of Waseda University (No. 58A–29 for 1983, No. 59A–56 for 1984, No. 60A–46 for 1985, No. 61A–69 for 1986 and No. 62A–79 for 1987) for this work (Parts II & III)

and related stratigraphic investigations by Hirano *et al.*

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(J) : in Japanese with English abstract or brief explanation.

(R): in Russian.

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本邦白亜系セノマニアン階産イノセラムス—III。北西太平洋地域によく産する3種：この論文ではソ連の太平洋地区だけでなく北海道からもよく産する次の3種を記載した。

（1）*Inoceramus pennatulus* Pergament：大型で左右不等殼，左殼の殼頂は突出する；殼の膨らみ中〜緩，後翼部が広い；肋は不規則である。Pergament (1966) は左殼の好例を複数図示したが，右殼の例が乏しかった。北海道の資料はこれを補足する。幾春別とオビラシベではセノマニアン上部に特徴的だが，大夕張や佐久では中部のやや下の方からも産している。

（2）*I. reduncus* Pergament：中〜やや大型で左右不等殼；左殼は膨らみが著しく，殼頂部は突出し内前方に強く屈曲する。成長の途中で膨らみの変化があり，くびれを伴う。成長初期の殼表面には細線・細輪が目立ち，肋は中年以降にやや強いのがあるが，概して不規則である。典型例はセノマニアン上部に産し，多分本種といえるものは中部にもある。

（3）*I. ginterensis* Pergament：典型的なものは中型で，弱不等殼，膨らみが緩慢で左殼頂も余り突出していない。輪郭は準卵形〜準長方形である。同心肋は通例初期に弱く，長期以降は中程度の強さかやや不規則；細線・細輪は幼年期によく示され，中期以降でも保存がよければ認められる。典型的なものがソ連太平洋区と北海道だけでなく，北米内陸地区にも普通に分布している。北海道ではセノマニアン上部に多く，中部にも産する。そして中部と上部のとの間で形質上の差は特に認められない。本種の先祖は *I. takahashii* Mataumoto et Noda 又はそれに近いものではなかろうか；また *I. heinzi* Sornay は本種に近縁らしい。

以上3種の層序的産出範囲はかなり長い。同様のことはソ連の太平洋側地域でも認められている。従来 *I. pennatulus* 帯を北海道ではセノマニアン上部に，ソ連太平洋区では中部に設けているが，必ずしも適切でない。　　松本達郎・浅井明人・平野弘道・野田雅之

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 149, pp. 396–416, 11 Figs., April 30, 1988

854. BARREMIAN AMMONITES FROM THE ISHIDO FORMATION, JAPAN – SUPPLEMENTS AND FAUNAL ANALYSIS* –

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Abstract. Six species belonging to five genera of Barremian ammonites are described from the Ishido Formation of the Sanchu Terrane in the Kwanto Mountains. They are: *Calliphylloceras* sp., *Karsteniceras asiaticum* (Yabe et Shimizu), *K. obatai* Matsukawa, *Heteroceras* (*Argvethites*) sp., *Barremites* (*Barremites*) *strettostoma*, and *Valdedorsella* (*Puezalpella*) sp. The ammonite fauna of the Ishido Formation (the Ishido fauna) is made up essentially of two groups of ammonites, the smooth or weakly ornate normaly coiled forms and various heteromorphs, a characteristic feature of the Barremian ammonite faunas generally in the Tethyan realm. The Ishido fauna shows a high similarity to that of the Mediterranean region of the Tethyan realm, and contains also one species, *Simbirskites* (*Milanowskia*) sp., which migrated from the northeast European province in the European-Boreal region through the Arctic epicontinental sea.

Introduction

The Ishido Formation is one of the best known Lower Cretaceous sequences seen in Japan. Since Yabe, Nagao and Shimizu (1926) described the stratigraphy and molluscan fossils of the Sanchu Cretaceous, many stratigraphical, sedimentological and paleontological studies have been published (see bibliography in Matsukawa 1983, Obata and Matsukawa 1984). Matsukawa (1983) has established the lithostratigraphy and molluscan biostratigraphy, and presumed sedimentary environments on the basis of a geological survey over the area of the Cretaceous formations. He used the cephalopods collected from the Ishido Formation in the inter-regional correlation. These cephalopods were identified and described by Obata *et al.* (1976) and Obata and Matsukawa (1984). However, some ammonites remain to be described.

This paper gives a description of five genera comprising six species of ammonites from the Ishido Formation. This completes the description of the 15 species belonging to 10 genera of ammonites obtained from this formation so far. The characteristics of the Ishido fauna are discussed and a comparison made with some faunas of other regions.

I thank Drs. I. Obata (National Science Museum, Tokyo), P. F. Rawson (University College, London), J. P. Thieuloy (Université de Grenoble), J. Wiedmann (Universität Tübingen), and H. G. Owen [British Museum (Natural History)] for their critical reading of the manuscript. I am also indebted to Drs. K. Tanabe (University of Tokyo), and M. Futakami (Kawamura-gakuen Women's University, Chiba) for providing fruitful discussion on certain problems. Thanks are extended to Drs. K. Tanaka (Shinshu University), T. Kotaka (Tohoku University) and I. Fujiyama (National Science Museum, Tokyo), and Messrs. T. Kinoshita (Tachikawa Dainana Junior High School, Tokyo), H. Tsuda (Shinagawa-ku, Tokyo) and Y. Ogawa (Manaus, Brazil) for their kind help in collecting the fossils described herein.

*Received October 29, 1987; revised manuscript accepted March 15, 1988.

This work is dedicated to the memory of my late mother who died suddenly during the writing of this paper. The study was financially supported in part by the Science Research Fund of the Japanese Ministry of Education, Science and Culture (Monbusho) (Obata, no. 56340041 for Cooperative Research in 1981 – 1982; Matsukawa, no. 56740335 in 1981 and no. 61740463 in 1986).

Geological setting

According to Matsukawa (1983), the Cretaceous strata of the Sanchu Terrane comprise clastic rocks that are almost 2700 m in thickness (Figs. 1, 2). These are characterized by three cyclic sequences, each one of which is thick with coarse-grained sediments at the base fining upward; each attain more than several hundred meters in thickness and show a changing environmental facies from nonmarine to marine beds. Although three sedimentary cycles are recognizable, the whole sequence is divided into four units named in ascending order the Shiroi, Ishido, Sebayashi and Sanyama Formations (Fig. 2). Ammonites occur in the Ishido and Sanyama Formations. Those in the Ishido Formation indicate as early to late Barremian age. Those from the Sanyama Formation indicate a late Aptian to early Cenomanian age. Hence the Sebayashi Formation, which lies between these two formations, is probably referable to the Uppermost Barremian to Aptian.

The nonmarine Shiroi Formation and overlying marine Ishido Formation represent the first cycle. These two formations successively onlap the structurally complex basement consisting of Jurassic and older rocks, and are interpreted as a transgressive sequence passing from fluvial to

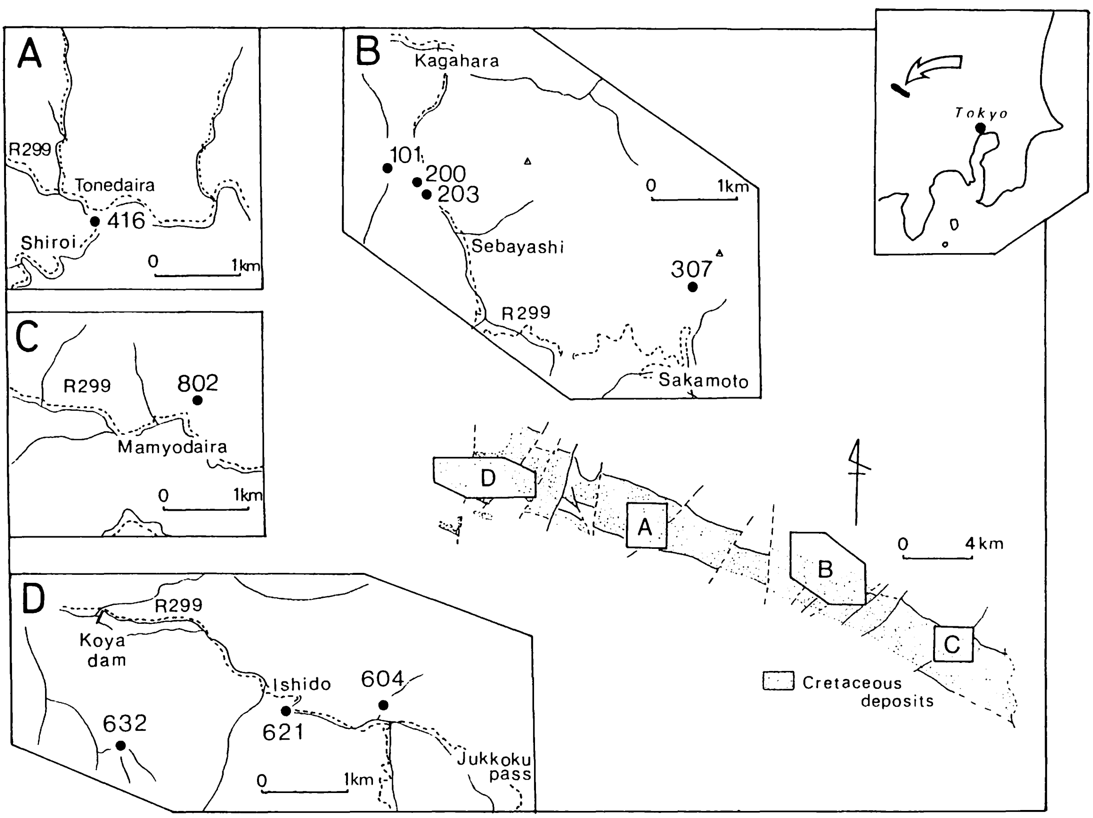


Figure 1. Map showing the ammonite localities. The prefix SA of the locality number is omitted.

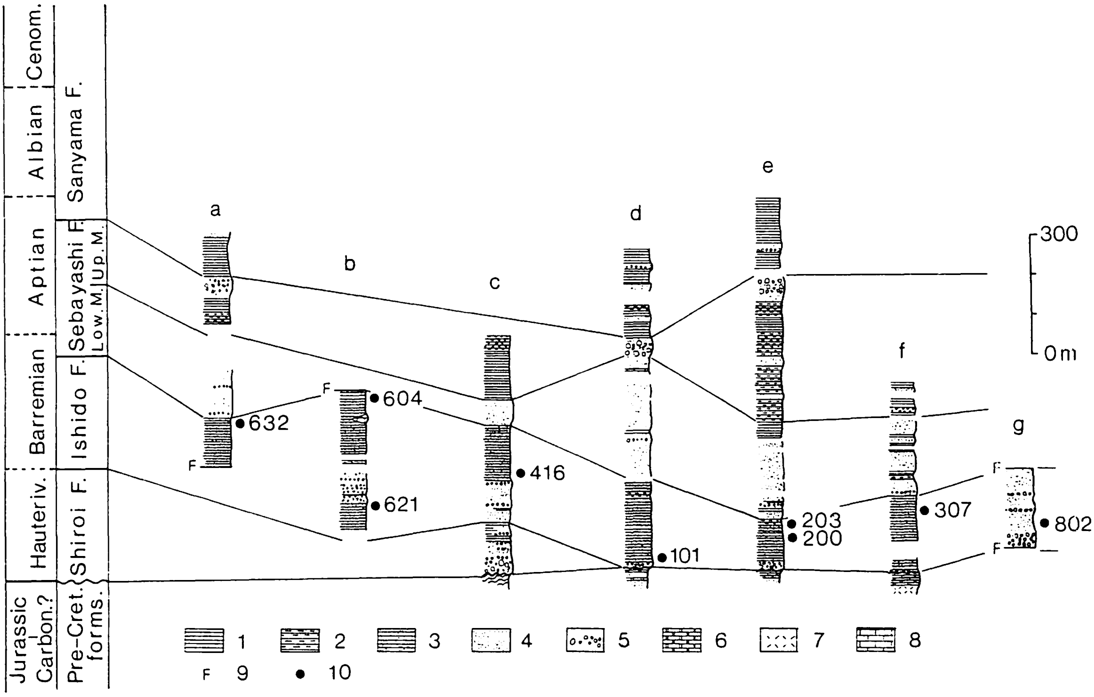


Figure 2. Individual columnar sections with the indication of the horizons which yielded ammonites. 1: Shale, 2: Alternating beds of sandstone and shale, 3: Muddy sandstone, 4: Sandstone, 5: Conglomerate, 6: Chert, 7: Pyroclastic rocks, 8: Limestone, 9: Fault, 10: Horizon yielding ammonites. a: Miyakozawa, b: Ishido, c: Shiroi, d: Myokezawa, e: Mamonozawa, f: Niheizawa, g: Mamyodaira.

epeiric embayment deposits.

Barremian ammonites were found in the Ishido Formation at 9 localities (Fig. 1) representing three different horizons. These horizons were confirmed in the Mamonozawa and Myokezawa valleys (Fig. 2). The characteristic species are as follows: *Barremites* (*B.*) *difficilis* (d'Orbigny), *Pulchellia ishidoensis* Yabe et Shimizu, *Simbirskites* (*Milanowskia*) sp. and others in the lower horizon; *Shasticrioceras* sp. aff. *S. patricki* Murphy and *Phylloceras* sp. from the middle horizon, and *Barremites* (*B.*) *strettostoma* (Uhlig), *Pseudohaploceras japonicum* Obata et Matsukawa, *Heteroceras* (*H.*) sp. aff. *H.* (*H.*) *astieri* d'Orbigny and others from the upper horizon. These ammonites are all of Barremian age.

Depository

The specimens with the prefix are preserved in the following institutions:

National Science Museum (NSM-PM), Tokyo
Institute of Geology and Paleontology, Tohoku University (IGPS), Sendai
Department of Geology, Faculty of General Education, Shinshu University (SGE), Matsumoto

Systematic description

Order Ammonoidea Zittel, 1884

Suborder Phylloceratina Arkell, 1950

Superfamily Phyllocerataceae Zittel, 1884

Family Phylloceratidae Zittel, 1884

Subfamily Calliphylloceratinae Spath, 1927

Genus *Calliphylloceras* Spath, 1927

Type species: *Phylloceras disputabile* Zittel, 1869, by original designation.

Calliphylloceras sp.

Figure 3-1

Material: NSM-PM 7531, an imperfect mold of shell.

Description: The specimen is about 45 mm in shell diameter. The shell is discoidal, involute and smooth. It has a very narrow and shallow umbilicus (U/D = 0.12) but with a low steep wall. The whorl is of compressed form being higher than broad (B/H = 0.27). The flanks are slightly inflated at the middle of whorl height, and slope rapidly to the periphery. The venter is narrow and sharp. The test is thin. Numerous subcostae are very densely arranged, rectiradiate with less sinuous curvature on the flank, and are gently arched on the venter. They are weak in the umbilical side, but become gradually conspicuous in the ventral side of flank. Each rib is as broad as the intercostal spaces. The constrictions are regular and frequent: four in a half volution. They show weak flexuosity on the internal mold, and are nearly parallel to the ribs. The suture is unknown.

Measurements (in mm):

Specimen	Diameter (D)	Umbilicus (U)	Height (H)	Breadth (B)	B/H
NSM-PM 7531	46.2(1)	5.4(0.12)	24.9	ca 6.7	ca 0.27

Remarks: The illustrated specimens of *Phylloceras aldersoni* Anderson (Anderson, 1938, p. 143, pl. 11, figs. 3–6) from the Aptian of California are similar to the present specimen in the umbilical ratio (U/D), the density and sigmoid form of costae and the weakly flexuous constrictions. The whorl section of the former is, however, much broader than the latter: the former having a ratio of breadth to height of 0.81 and the latter, 0.27. Furthermore, the numerous costae are well marked on the whole whorl flank, whereas they are present only on the outer half flank in the latter.

Phylloceras sp. illustrated by Obata and Matsukawa (1984, p. 16, pl. 4, figs. 1a, b) from the Upper Barremian of the Ishido Formation differs from the present specimen in having flexuous constrictions.

The present specimen belongs to the genus *Calliphylloeras* (Wright, 1957, L189) on the basis of smooth, involute and compressed shell, periodic sigmoid constrictions on internal mold and numerous costae.

However, this form from the Ishido Formation can not, by reason of insufficient preservation, be assigned to a definite species at present.

Occurrence: Loc. SA-203.

Suborder Ancyloceratina Wiedmann, 1966

Superfamily Ancylocerataceae Meek, 1876

Family Ancyloceratidae Meek, 1876

Subfamily Ancyloceratinae Meek, 1876

Remarks: The classification of the Ancyloceratinae adopted here has been discussed already in Matsukawa (1987).

Genus *Karsteniceras* Royo y Gomez, 1945

Remarks: The generic characters are discussed in Matsukawa (1987).

Type species: *Ancyloceras beyrichii* Karsten, 1858, by original designation.

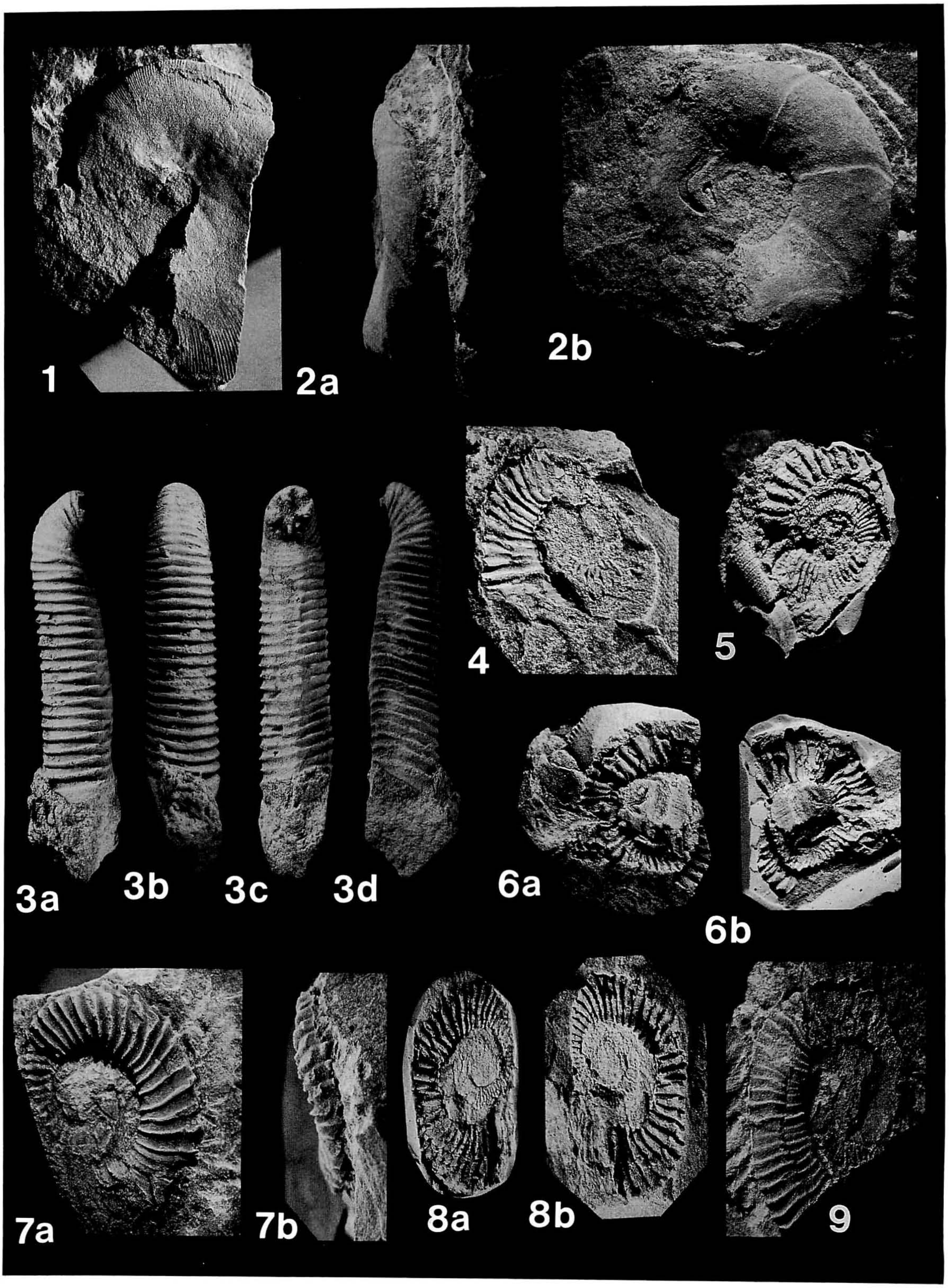
Karsteniceras asiaticum (Yabe et Shimizu)

Figures 3-4, 5, 6a, b; 4

1926 *Leptoceras asiaticum* Yabe et Shimizu, p. 73, pl. 15, fig. 21.

Material: IGPS 22849, the holotype, described by Yabe and Shimizu (1926) in Yabe *et al.* SGE-008 and 009 specimens collected by K. Tanaka.

Description: The shell is small, about 18 mm in maximum diameter, coiled in a loose spire. The whorl is crioceratid with regular open spire and with a part of the last volution closely approaching the next inner one until at least one and half volutions. The whorl section is subrectangular, nearly flat on the flanks and rounded on the venter which bears a siphonal groove. The whorl is ornamented with numerous, almost radial, narrow ribs which are separated by broader interspaces. The intercostal areas are twice or three times as broad as the rursiradiate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8b
9

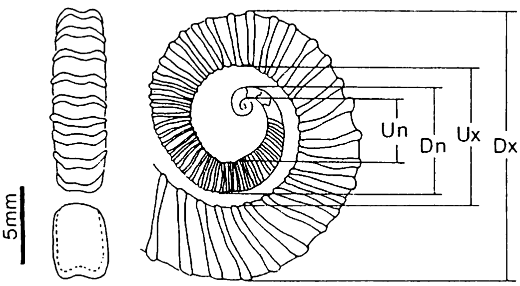


Figure 4. *Karsteniceras asiaticum* (Yabe et Shimizu). (Right) Lateral view; (Left upper) Ventral view; (Left lower) Whorl section. The diagram also represents the measuring-distances.

ribs on the outer volution (adult stage), but are crowded in the inner volution of the young stage, where they are interrupted on the venter. There are about 20 ribs on the outer volution. The suture exhibits a characteristic trifid lateral lobe.

Measurements: (in mm);

In Fig. 4, Dx = maximum diameter of loose spire; Dn = minimum diameter of loose spire; H = whorl height in maximum diameter of loose spire; B = whorl breadth in maximum diameter of loose spire; Ux = maximum umbilical gap; Un = minimum umbilical gap.

Specimens	Dx	Dn	H	B(B/H)	Ux	Un	Ux/Dx	Un/Dn
IGPS 22894	18.0	12.6	4.4	–	8.7	5.8	.48	.46
SGE-008	16.0	14.0	3.6	1.5(.42)	8.5	7.9	.53	.56
SGE-009	16.2	8.5	4.9	–	7.9	4.5	.48	.52

Variation: The percentage ratio of maximum umbilical gap to maximum diameter of the loose spire shows a range from 0.48 to 0.53, the percentage ratio of minimum umbilical gap to minimum diameter of loose spire is from 0.46 to 0.56.

Remarks: The present species is similar to *Karsteniceras beyrichii* (Karsten) (Royo y Gomez, 1945, p. 460–461, pl. 1, fig. 1), the type species of the genus from the Barremian of Colombia, in its coiling characteristics. However, the whorl section of the former is subrectangular with nearly flat flanks throughout all stages. Furthermore, the interspaces between ribs of the Sanchu specimen are broader than in the Colombian form, the latter being twice or three times as broad as the ribs in the former, but equal to the breadth of the ribs in the latter. On the basis of the subsequent description of *K. beyrichii* (Karsten) by Etayo Serna (1968, p. 54–56, pl. 1, figs. 1–3, 5, 7), this species can be also distinguished by the pattern of its rursiradiate ribs.

Occurrence: Loc. SA-621.

Karsteniceras obatai Matsukawa

Figures 3-7a, b, 8a, b, 9; 5

1926 *Ancyloceras*? sp., Yabe and Shimizu in Yabe *et al.*, p. 71, pl. 15, figs. 12, 13.

1987 *Karsteniceras obatai* Matsukawa, p. 349–354, fig. 3.

Material: SGE-005, collected by H. Kumai; SGE-006, -007, -010 collected by K. Tanaka.

Measurements: (in mm); (See Fig. 4 for explanation of the symbols used).

Specimens	Dx	Dn	H	B	Ux	Un	Ux/Dx	Un/Dn
SGE-005	14.1	11.2	4.0	–	7.2	5.1	.51	.45
SGE-007	19.8	11.4	5.4	–	10.2	5.4	.52	.47
SGE-010	13.3	9.8	3.6	–	6.7	4.6	.50	.47

Comparison: The present species is allied, in its coiling, to *Karsteniceras balernaense* Rieber (Rieber, 1977, p. 779–781, pl. 1, fig. 2) from the Barremian of Switzerland, but is distinguished by different ornamentation. In *K. obatai,* surface of the later shell (e.g. about 10 mm in diameter of NSM-PM9589) is covered with numerous lirae. In *K. balernaense,* surface

← **Figure 3.** 1, *Calliphylloceras* sp., late Barremian, uppermost part of the formation, from loc. SA-203, NSM-PM 7531, lateral view, x 1.2. 2, *Valdedorsella* (*Puezalpella*) sp., late Barremian, upper part of the formation, from loc. SA-307, NSM-PM 7532, ventral (a) and lateral (b) views, x 1.0. 3, *Heteroceras* (*Argvethites*) sp., late Barremian, uppermost part of the formation, from loc. SA-203, NSM-PM 7294, lateral (a, d), ventral (b) and dorsal (c) views, x 1.0. 4, 5, 6, *Karsteniceras asiaticum* (Yabe et Shimizu), early Barremian, lower part of the formation, from loc. SA-621. Holotype, IGPS 22847 (5) and SGE-009 (4), SGE-008 (6): rubber cast (b) from mold (a), lateral views, x 1.7. 7, 8, 9, *Karsteniceras obatai* Matsukawa, early Barremian, lower part of the formation, from loc. SA-621. SEG-005 (7), SEG-007 (8) and SEG-006 (9): rubber cast (8a) from mold (8b); lateral (7a, 8a, b, 9) and ventral (7b) views, x 2.5 (7), x 1.8 (8) and x 2.0 (9).

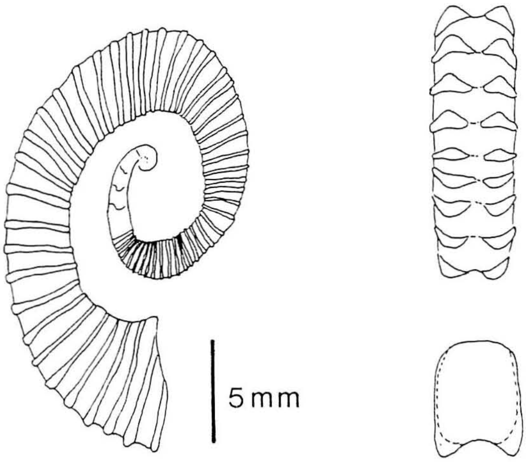


Figure 5. *Karsteniceras obatai* Matsukawa. (Left) Lateral view; (Right upper) Ventral view; (Right lower) Whorl section.

of the later shell (*e.g.* about 20 mm in diameter of the type specimen) is covered with ribbing.

Occurrence: Loc. SA-621.

Genus *Heteroceras* d'Orbigny, 1850

Type species: *Heteroceras emericianum,* subsequent designation by Meek, 1876.

Subgenus *Argvethites* Rouchadge, 1933

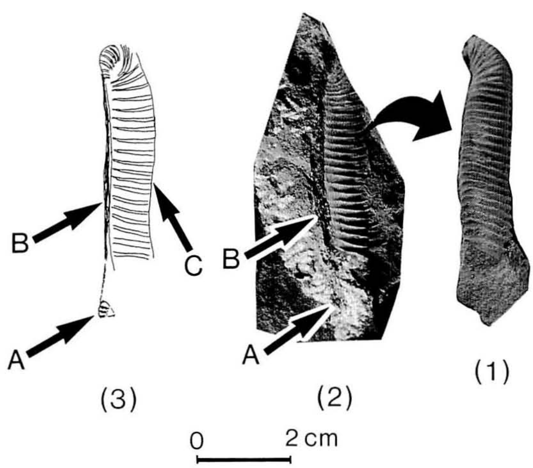


Figure 6. *Heteroceras* (*Argvethites*) sp. A: Helix, B: First shaft, C: Second shaft. (1) Internal mold of second shaft, (2) Helix, first shaft and second shaft of NSM-PM 7294, (3) Drawing of the same specimen to show the position of the helix and first shaft.

Type species: Heteroceras (*Argvethites*) *lashense* Rouchadze, by original designation.

Heteroceras (*Argvethites*) sp.

Figures 3-3a, b, c, d; 6

1976 *Anahamulina* aff. *subcylindrica* (d'Orbigny), Obata *et al.*, figs. 6-2, pl. 2, fig. 2.

Material: NSM-PM7294, an imperfect internal mold of shell, collected by H. Tsuda.

Description: This specimen consists of two main parts, an initial helix and shaft. The last helical whorl passes directly into the first shaft which is flattened laterally. The first shaft is long, being about four-fifth as long as the second shaft and almost parallel to the second one.

The helix is small in size. The general outline of the helix is roughly triangular, with an apical angle of about 60 degrees. The helical whorls are contiguous and ornamented by twisted single ribs.

The second shaft is located on a level with the top of breadth along the length. The second shaft is nearly circular in cross section, having a ratio of 1.1 in B/H at the larger end and a ratio of 1.2 at the smaller end. The annular ribs are elevated, slender, slightly sharpened at the top, but are low on the dorsum. In the second shaft at the later stage, the ribs are slightly flexuous or rectiradiate on the flanks, and separated by interspaces which are three times as broad as the ribs. At the bent part of the second shaft, the whorl has a shallow groove, and the ribs weaken on the dorsum and are divided into primaries and secondaries branching at the ventral-shoulder. The suture line is of *Ancyloceras* type but is only partially visible and not in detail.

Measurements (in mm) of the specimen are as follows: height of total helix = 3.2, length of second shaft = 50.2, whorl-height at larger end of second shaft = 11.3, whorl-breadth at larger end of second shaft = 12.1, whorl-height at smaller end of second shaft = 7.8, whorl-breadth at smaller end of second shaft = 9.3.

Remarks: The present specimen is similar, in its whorl section, to the illustrated specimen of *Crioceras furcatum* (Simionescu, 1898, p. 146, pl. 4, figs. 7a, b) from the Barremian of Romania. The latter was listed subsequently by Patrulius (1969) as *Toxoceratoides subfurcatum*, sp. nov. This is a view also held by J. P. Thieuloy (personal communication, Descember 1986). However, the venter of bent part of the former is slightly grooved without interruption of ribs.

Anyhow, the present specimen belongs to the subgenus *Argvethites* (Wright, 1957, L212) on the basis of aperture level with top of helix. However, this form from the Ishido Formation cannot, by reason of insufficient preservation, be assigned to a definite species at present.

Occurrence: Loc. SA-203.

Suborder Ammonitina Hyatt, 1900

Superfamily Desmocerataceae Zittel, 1895

Family Eodesmoceratidae Wright, 1955

Subfamily Eodesmoceratinae Wright, 1955

Genus *Barremites* Kilian, 1913

Type species: *Ammonites difficilis* d'Orbigny 1841, by original designation.

Subgenus *Barremites* Wright, 1953

Type species: *Ammonites difficilis* d'Orbigny 1841, by original designation.

Barremites (*Barremites*) *strettostoma* (Uhlig)

Figures 8-4, 5a, b, c

1976 *Barremites* (*Barremites*) sp. aff. *B. strettostoma* Obata *et al.*, p. 128–129, pl. 1, fig. 1, pl. 2, fig. 4.
1984 *Barremites* (*Barremites*) sp. aff. *B. strettostoma* Obata and Matsukawa, p. 21, pl. 1, figs. 1a, b, 3.

Material: See Obata *et al.* (1976).

Remarks: *Barremites* (*Barremites*) sp. aff. *B. strettostoma* from the Sanchu Cretaceous has been described by Obata *et al.* (1976) and Obata and Matsukawa (1984). This form was distinguished from *B.* (*B.*) *strettostoma* by differences in certain minor characters shown by the two syntypes of *Haploceras strettostoma* by Uhlig (1883, p. 225, pl. 17, figs. 3, 4), from the Wernsdorfer Schichten in Silesia (Poland), and the several hypotypes of *Desmoceras strettostoma* figured by Karakasch (1907, p. 72–73, pl. 5, figs. 3–5; pl. 6, fig. 5), from the sequence in the Sably Mine in Crimea. The species from the Sanchu Cretaceous has ratios of 0.13 to 0.18 in U/D and 0.36 to 0.60 in B/H; the Silesian species has ratios of 0.10 to 0.11 in U/D and 0.41 in B/H by estimate; the Crimean species has ratios of 0.10 to 0.16 in U/D and 0.46 to 0.60 in B/H. Although the Sanchu specimens are smaller than the Silesian and Crimean ones, they may be included within the range of variation of a single species. Thirty four specimens from loc. SA-203 are less than 25 mm in diameter. Besides, the subangular shoulder of ventro-lateral periphery, which is the other difference between the Japanese specimens and the Crimean ones, is recognizable in the all of Japanese specimens but only in the middle portion of one of the Crimean ones (Karakasch, 1907, pl. 5, fig. 3).

To sum up, the Sanchu specimens represent *Barremites* (*Barremites*) *strettostoma*.

Subfamily Puzosiinae Spath, 1922

Genus *Valdedorsella* Breistroffer, 1947

Type species: Desmoceras akushaense Anthula, 1899 (designated by Breistroffer, 1947).

Subgenus *Puezalpella* Dimitrova, 1967

Type species: *Desmoceras uhligi* Haug, 1889, by original designation.

Valdedorsella (*Puezalpella*) sp.

Figures 3-2a, b

Material: NSM-PM 7532, an imperfect mold of a shell, in which the inner whorl is not preserved.

Description: The specimen is about 46 mm in diameter of shell. The shell is compressed, evolute, smooth, having a somewhat angular whorl section. The whorl is high and much compressed (B/H = 0.52). The breadth is at a maximum about two-thirds of the flank height above the umbilical margin. The flanks are slightly inflated. The umbilicus is of narrow width (19%) in proportion to the diameter and is surrounded by a sloping wall. The shell surface is ornamented with four distinct straight constrictions which are concave on the whorl flank, becoming strongly prorsiradiate near the venter over which they cross. The suture line is unknown.

Measurements (in mm);

Specimen	Diameter (D)	Umbilicus (U)	Height (H)	Breadth (B)	B/H
NSM-PM 7532	46+	8.8(0.19)	17.7		
			15.9	8.3	0.52

Remarks: The present specimen is distinguished from the illustrated specimen of *Puzosia melchioris* (Karakash, 1907, p. 75–76, pl. 7, fig. 4a, b) from the Barremian of Crimea in the umbilical ratio (U/D): the former is narrow (0.19), but the latter is wide (0.30).

Valdedorsella (*Puezalpella*) *uhligi* (Haug, 1889) illustrated by Dimitrova (1967, pl. 69, figs. 4, 4a; pl. 72, fig. 1, 1a, 2, 2a) from the Aptian of Bulgaria differs from the present specimen in having a wide umbilicus. However, the Sanchu specimen is too incomplete to make a specific determination.

Occurrence: Lc. SA-307.

Faunal analysis

[1] Characteristics of assemblages.

The ammonite assemblages of the Ishido Formation are made up of three morphotypes: smooth or weakly ornate ammonites (66 individuals being classified with at least 7 species belonging to 5 genera of the Phylloceratidae, Desmoceratidae and Eodesmoceratidae), heteromorph ammonites (40 individuals, with at least 6 species of belonging to 5 genera of the Ancyloceratidae and Heteroceratidae) and ornate ammonites (6 individuals representing 2 species of 2 genera belonging respectively to the Olcostephanidae and Pulchellidae) (Table 1). The assemblages show a predomination of smooth or weakly ornate ammonites with the heteromorph ammonites providing a higher range of morphological diversity (Fig. 7).

The composition of species, number of individuals and preservation of ammonite assemblages in the Ishido Formation differ from

Table 1. List of ammonite species from the Ishido Formation.

Specific name \ Locality number	632	621	604	416	100	101	200	203	307	802	Total
Phylloceras sp.							1				1
Calliphylloceras sp.								1			1
Phylloceratidae gen. et sp. indet.								1			1
Bochianitidae gen. et sp. indet.								1			1
Shasticrioceras sp. aff. *S. patricki* MURPHY							1				1
Karsteniceras asiaticum (YABE et SHIMIZU)		3(1)									3
K. obatai MATSUKAWA		5(1)									5
Ancyloceratidae gen. et sp. indet.	1	1			1	3		4			10
Heteroceras (*H.*) sp. aff. *H. astieri* d'ORBIGNY								4	1		5
H. (*H.*) sp.			1					8			9
H. (*Argvethites*) sp.								1			1
Heteroceratidae gen et sp. indet.								5			5
Ptychoceratidae gen. et sp. indet.								1			1
Simbirskites (*Milanowskia*) sp.		1				1					2
Valdedorsella (*Puezalpella*) sp.									2		2
Barremites (*B.*) *difficilis* (d'ORBIGNY)		4(1)									4
B. (*B.*) *strettostoma* (UHLIG)				1				34	1	2	38
B. (*B.*) sp.								16	1		17
Pseudohaploceras japonicum OBATA et MATSUKAWA								2			2
Pulchellia ishidoensis YABE et SHIMIZU		4(1)									4
Total	1	18	1	1	1	4	2	77	5	2	112

Numbers in parentheses are taken from Yabe, Nagao and Shimizu (1926).

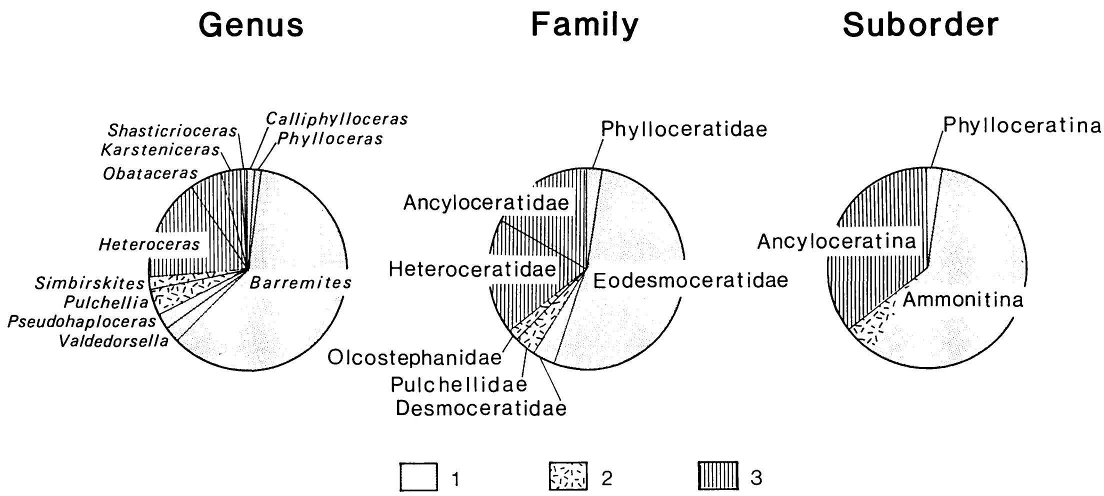
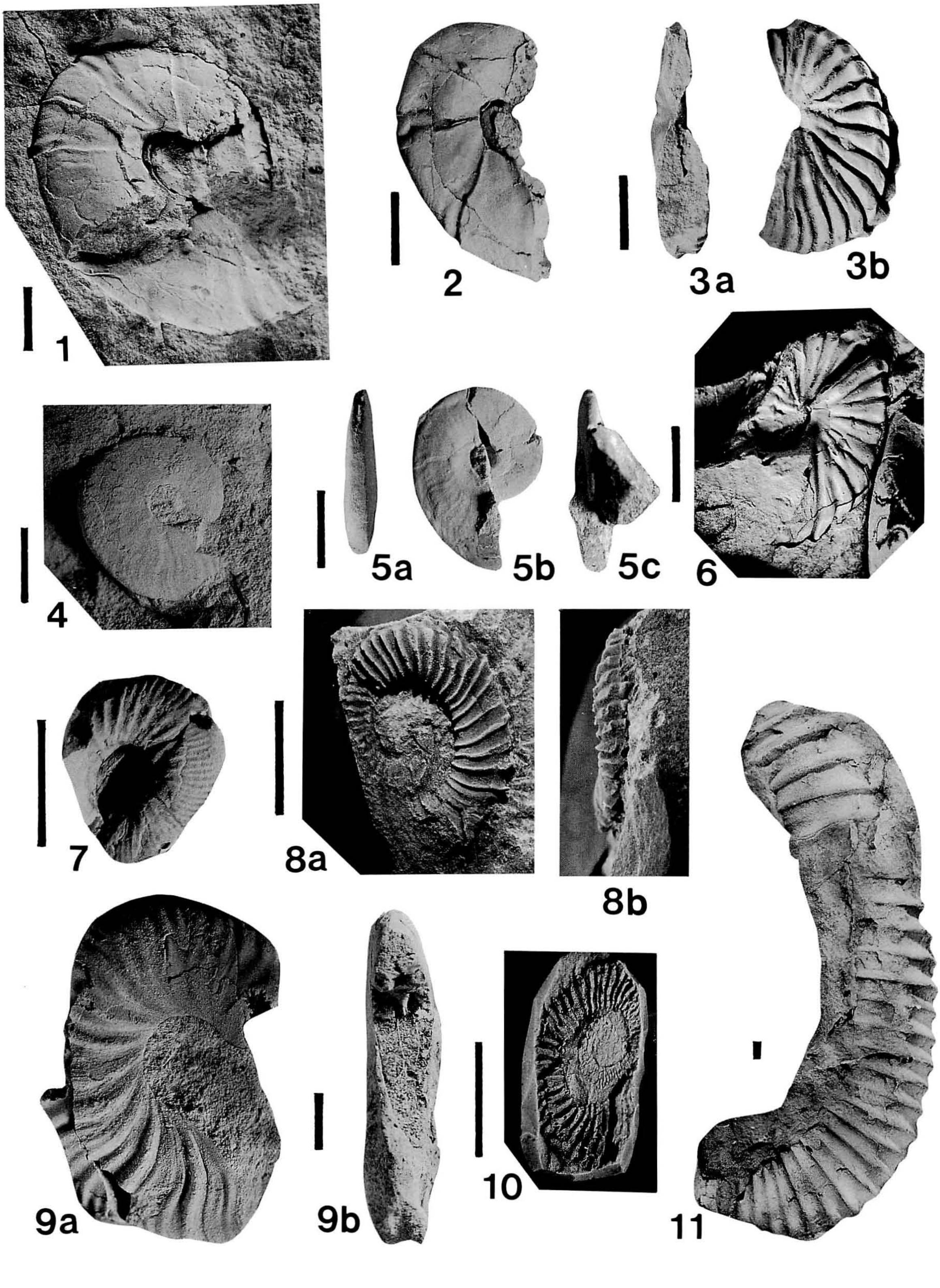


Figure 7. Circular diagrams displaying the occurrence of ammonite species in the Ishido Formation at genus, family, suborder levels and proportions of morphotypes of smooth or weakly ornate ammonites (1), ornate ammonites (2) and heteromorph ammonites (3). They are shown in the frequency of individual occurrences of ammonite species belonging to genus, family and suborder.

place to place and horizon to horizon. In particular, at Loc. SA-621 (lower part of the formation in the western area) and Loc. SA-203 (eastern uppermost part in the eastern area), many ammonite species occur along with a large number of bivalve species including trigonians (Table 1; see table 2 in Matsukawa, 1983). The body chambers, phragmocones and fine ornament of these ammonite specimens are generally well preserved, although the body chambers and phragmocones of large-sized specimens from Loc. SA-203 are partly broken. Judging from the features described above, these assemblages may be showing evidence of biocoenose or thanatocoenose conditions. The degree of crushing of the inner whorl of specimens from Loc. SA-621 is different according to which genera the specimens belong (Fig. 8). The specimens of *Barremites* (smooth or weakly ornate ammonites) and *Karsteniceras* (heteromorph ammonites) are crushed flat, but the specimens of *Pulchellia* (ornate ammonites) nearly retain their original form. This is interpreted as an indication of differences in the strength of the shells between various genera or coiling types against the crushing forces of the compacting sediments in which they have been buried. On the other hand, as the broken specimens of ammonites of large size and loosely spiral shells from Loc. 203, possess fine ornament well preserved, it is suggested that they have been transported a short distance and to have been broken up by wave action upon a shore. These occurrences contrast strikingly with those of bivalves collected from the same localities (described below).

So far as the associated bivalves which show epifauna or infauna in mode of living are concerned, they are probably still close to their original living places. This is suggested by their good state of preservation with conjoined shells in poorly sorted muddy sandstone, the number of large shells, that is, *Gervillaria haradae* and *Pterotrigonia* (*P.*) *hokkaidoana*, at Loc. SA-203, and those with unabraded finely ornamented valves, that is, *Grammatodon* (*Nanonavis*) *yokoyamai* and *Astarte* (*A.*) *subsenecta*, at Loc. SA-621. The bivalve fauna is considered to consist of shallow marine inhabitants.

Consequently, ammonites and bivalves can be interpreted as inhabiting a shallow marine embayment, and to have migrated eastward in response to the transgression of the Ishido Sea.


1
2
3a
3b
4
5a
5b
5c
6
7
8a
8b
9a
9b
10
11

[2] Comparison with some facies and environments containing ammonite assemblages in other regions.

According to Kakabadze (1979), in the southern USSR (Crimea, Caucasus and Middle Asia) the ammonite assemblages, lithofacies and environments of the Hauterivian to Barremian are summarized as follows: (1) the abundant assemblages are made up of heteromorph ammonites, smooth or weakly ornate ammonites and ornate ammonites in ascending order, (2) the assemblages are included in the lime-rich lithofacies which are divided into five types interpreted to be deposited in relatively shallow sublittoral and infralittoral environments, (3) the heteromorph ammonites show the highest morphological diversity, and (4) the smooth or weakly ornate ammonites tend to increase in numbers proportionally to the occurrence of finer deposits which indicate a deeper water environment.

Thus, features of ammonite occurrences in the southern USSR are similar to those of the Ishido Formation in Japan. There are, however, some differences in lithofacies and presumed environments: the sequence in the USSR is considered to be sublittoral and infralittoral, but the Japanese sequence indicates an epeiric shallow marine environment. The similar relation between ammonite assemblages and lime-rich lithofacies in southern USSR is also recognized in the Barremian stratotype at Angles in France (Busnardo, 1965).

The features as described above suggest that the Barremian ammonite fauna generally in these geographic regions can be interpreted as being made up of three morphological groups of ammonites, the heteromorphs and smooth or weakly ornate ammonites predominating, the ornate ammonites being of secondary importance and the fauna as a whole indicates a shallow marine habitat.

It is worthy of note that the habitats of ammonite faunas in the Upper Cretaceous in Japan have been divided also into different environments based on morphotypes (Matsumoto, 1965; Matsumoto and Okada, 1973; Tanaka, 1963; Tanabe, 1979; Tanabe, Obata and Futakami, 1978). Smooth or weakly ornate ammonites (*e.g.* desmoceratacean and lytoceratacean) are considered to indicate an offshore inhabitat, whereas ornate morphotype ammonites (*e.g.* the hoplitaceans) are considered to indicate coastal sea habitat.

From the facts as described above, there is a possibility that the habitat of ammonite faunas splits off during the period ranging from the Early to Late Cretaceous.

[3] Comparison with some faunas of other regions.

The ammonite bearing strata of the Ishido Formation is considered here to be a key to the inter-regional correlation among the Mediterranean, Circum Pacific and European-Boreal regions based on the occurrence of some characteristic genera: the Mediterranean, Tethyan region is represented by *Barremites* and *Pulchellia*, the Circum Pacific region by *Shasticrioceras* and the European-Boreal region by *Simbirskites* (Matsukawa, 1983; Obata and Matsukawa, 1988). Here, the following facts are noted: (1) The genus *Simbirskites*, one of the characteristic genera in the Upper Hauterivian of the European-Boreal region extending into the early Barremian, and the genus *Barremites* and *Pulchellia* which are indices of the Barremian in the Mediterranean region, are contained in one and the same bed of the lower part of the Ishido Formation, (2) The Ishido Formation in Japan and the Ono Formation in California contain some Tethyan ammonites though these two areas belong to the Circum Pacific region.

As to the first problem, *Simbirskites* (*Milanowskia*) sp. was collected from the Loc. SA-621 (in the western area) and Loc. SA-101 (in the

← **Figure 8.** Comparison of the mode of occurrence of ammonites from two localities, Loc. SA-621 (1–3b, 6–8b, 10) and Loc. SA-203 (4–5c, 9a, b, 11). 1, 2: *Barremites* (*Barremites*) *difficilis*; 3a, b, 6: *Pulchellia ishidoensis*; 4, 5a, b, c: *Barremites* (*B.*) *strettostoma*; 7: *Simbirskites* (*Milanowskia*) sp.; 8a, b, 10: *Karsteniceras obatai*; 9a, b: *Pseudohaploceras japonicum*; 11: *Heteroceras* (*H.*) sp. aff. *H. astieri.* Scale bars show 1 cm.

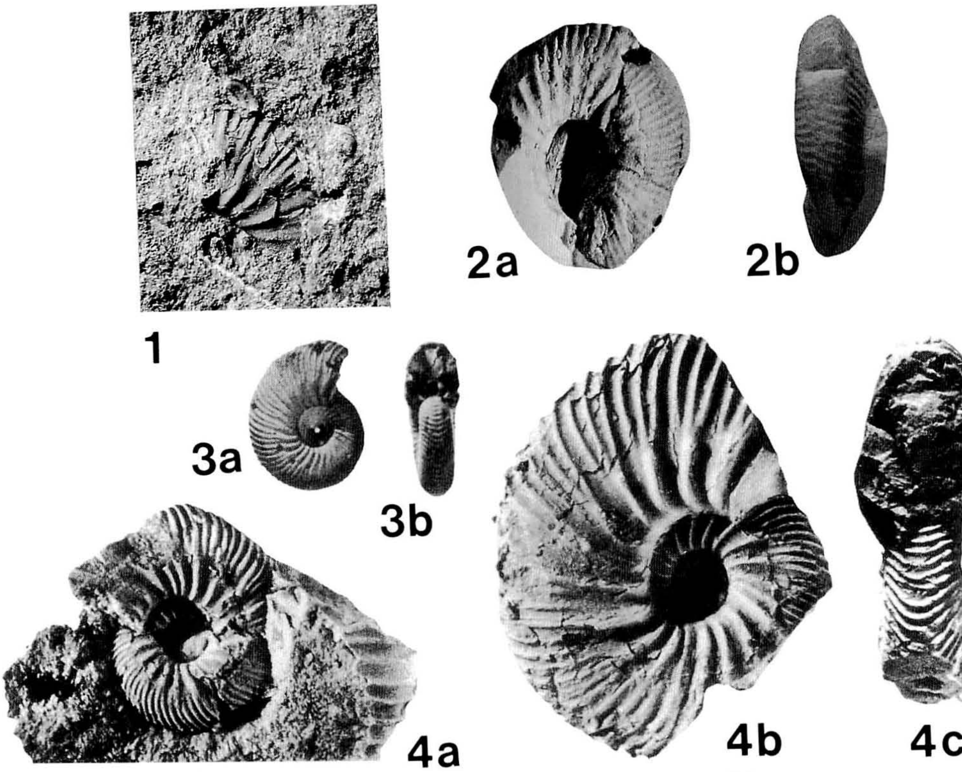


Figure 9. Comparison with *Simbirskites* (*Milanowskia*) sp. (INSM-PM 9515; 2a, b: IGPS 22847) from the Ishido Formation and *Simbirskites* (*Milanowskia*) *speetonensis* (Young et Bird) from the Speeton Clay (3a, b) and Ulyanovsk (formerly Simbirsk), Russia (4a, b, c). Taken from Obata and Matsukawa (1984) for 1, 2a, b and Rawson (1971a) for 3a–4c. The figures are x 2.0 (1, 2a, b) and natural size (3a, b, 4a, b, c).

eastern area). From each locality only one specimen was collected by Yabe and Shimizu, and by the author, respectively (Table 1). This species is somewhat similar to *Simbirskites* (*Milanowskia*) *speetonensis* (Young et Bird) from the part of the Speeton Clay (assigned to the lowest quarter of the Upper Hauterivian) in England (Obata and Matsukawa, 1984) (Fig. 9).

Loc. SA-621 is a cliff section, 30 m high, exposing muddy sandstone beds. In the lower part, at about 10 m above the base of the cliff, there is a horizon which yields mollusks and ammonites. If the *Simbirskites* (*Milanowskia*) sp. which was originally described by Yabe *et al.* (1926) as *Simbirskites kochibei*, was collected from this fossiliferous bed, the boundary between the Hauterivian and Barremian can be placed below the bed.

However, a thick pile of marine clastic sediments accumulated rapidly in the Sanchu area (for instance, the Ishido Formation corresponding to one part of the Barremian attains 500 m in thickness) and it might be difficult to make an exact comparison between the horizon at 10 m in SA-621 and about 27 m of C6 to LB5 bed (Upper Hauterivian to Lower Barremian) in the Speeton Clay.

Until now only two specimens of the genus *Simbirskites* have been found at two localities in the lower part of the Ishido Formation. The genus is one of those characteristic of the Upper Hauterivian of the European-Boreal region extending into the earliest Barremian (Rawson 1971a, 1983; Rawson and Mutterlose, 1983; Kemper 1973): with a distribution, geographically, mainly in northern Europe, the Urals, Arctic Canada, northern Siberia and the northern Pacific Coast regions of the Arctic-Boreal

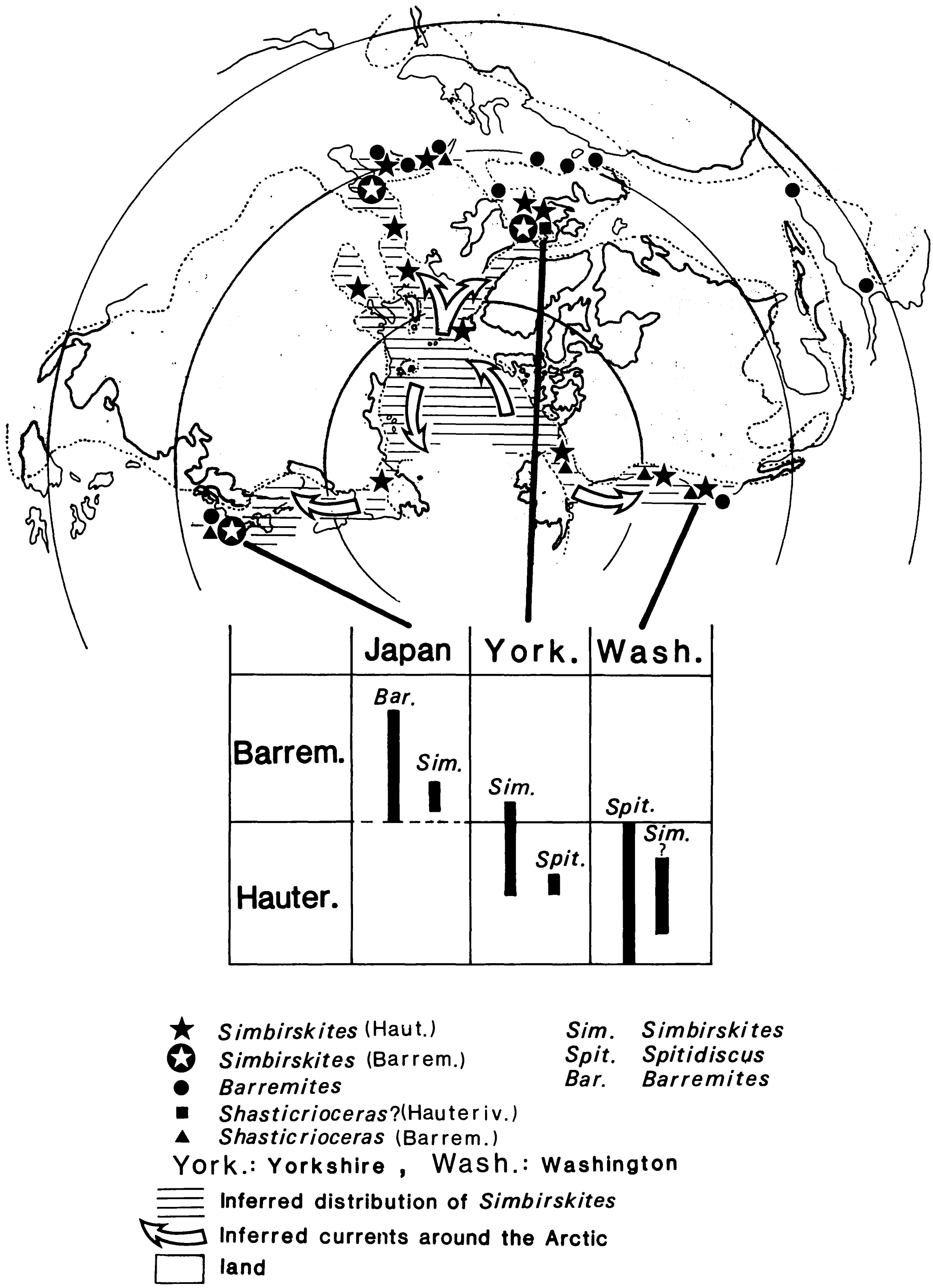


Figure 10. Occurrence and comparison of stratigraphical range of the genus *Simbirskites*. Continental position after Smith *et al.* (1981). Coastlines compiled from Jeletzky (1970), Kauffman (1973) and Ziegler (1982). Biostratigraphy is based on Rawson (1971b, 1983), Imley (1960), Kemper *et al.* (1981) and Matsukawa (1983). Oceanic circulation adapted from Obata and Matsukawa (1987).

Table 2. Distribution of Barremian fauna. 1: Yorkshire, 2: Hannover, 3: Wernsdorfer, 4: Angles, 5: Bulgaria, 6: north Caucasus and Crimea, 7: Madagascar, 8: the Arctic Canada, 9: Pacific slope of Canada, 10: Ono, 11: Boyaca, 12: Ishido. For references see text.

Genera \ Faunas	1	2	3	4	5	6	7	8	9	10	11	12
Phylloceras			●	●						●		●
Partschiceras					●				●	●		
Phyllopachyceras			●	●	●	●	●					
Calliphylloceras												●
Euphylloceras					●	●						
Salfediella				●	●	●						
Sowerbyceras			●									
Biasaloceras					●	●						
Lytoceras		●	●	●						●		
Eulytoceras			●	●	●	●	●		●	●		
Argonauticeras?									●			
Eotetragonites									●			
Protetragonites			●		●	●			●			
Pseudotetragonites						●						
Costidiscus			●	●	●	●			●			
Macroscaphites			●	●								
Acantholytoceras			●									
Crioceratites	●	●	●	●	●	●						
Toxoceras		●								●		
Hoplocrioceras	●	●			●			●	●			
Shasticrioceras					●			●	●	●		●
Pedioceras								●			●	
Paracyloceras		●										
Karsteniceras			●		●	●					●	●
Simancyloceras		●										
Protacrioceras					●		●					
Acrioceras			●	●	●			●	●			
Dissimilites				●						●		
Uhligia		●										
Paraspinoceras					●							
Ancyloceras		●	●	●		●		●	●	●	●	
Hamiticeras									●			
Toxoceratoides									●	●		
Heteroceras			●	●	●				●	●		●
Hemibaculites						●			●			
Colchidites						●					●	
Imerites					●							
Balearites					●							
Hemihoplites				●					●	●		
Matheronites					●	●						
Anahamulina			●	●	●	●				●		
Hamulina		●	●	●	●				●		●	
Hamulinites			●		●							
Euptychoceras					●					●		
Ptychoceras			●	●		●						
Leolissoceras					●							
Aconeceras		●						●	●			

(to be continued)

Olcostephanus			●		●							
Simbirskites	●					●						●
Barremites			●	●	●	●				●	●	●
Subsynella					●							
Valdedorsella					●	●						●
Pseudohaploceras			●		●						●	●
Callizoniceras		●										
Melchiorites			●	●	●						●	
Spitidiscus		●		●	●	●						
Plesiospitidiscus					●							
Holcodiscus			●	●	●	●						
Parasaynoceras											●	
Astieridiscus				●	●	●						
Silesites			●	●		●						
Nicklesia				●		●					●	
Pulchellia			●	●	●					●	●	●
Carstenia					●							
Subpulchellia				●								
Psilotissotia											●	
Paraspiticeras			●		●							
Parahoplites				●								

province (Fig. 10). It extends into the early Barremian, however, and the coincidence of the many specimens of the genera *Barremites, Pulchellia, Karsteniceras* and other species in the lower part of the Ishido Formation, having something in common with the Barremian ammonite faunas in the Mediterranean region, indicates not only an early Barremian age for the Japanese examples of *Simbirskites* (*Milanowskia*), but also an intermingling of Boreal and Tethyan forms in this region.

The *Simbirskites* species in the Ishido Formation probably migrated from the northwest European province via the Arctic regions to Sanchu. The occurrence of *Simbirskites* with Mediterranean ammonites in the lowest Barremian has been recognized also in northwest Europe (Kemper *et al.*, 1981) and in the Caucasus and Crimea (Kakabadze, 1983).

As to the second problem, I list Barremian ammonite genera from the world (Table 2): Yorkshire and Hannover in the northwest European province and the Arctic Canadian province as the European-Boreal region, Wernsdorfer in Silesia (Poland), Angles in France, Bulgaria and north Caucasus and Crimea as the Mediterranean region, Madagascar as the Indian region, and Pacific slope of Canada and Ono, California in the northeast Pacific province, Boyaca, Colombia in the southeast Pacific province, and Ishido, Japan in the northwest Pacific province as the Circum Pacific region.

The data on faunas outside Japan are based on the following references: for the Yoskshire fauna Spath (1924), Rawson (1971a, b) and Rawson and Mutterlose (1983), the Hannover fauna Koenen (1902) and Kemper (1976), the Wernsdorfer fauna Uhlig (1883) and Văsiček (1972), the Angles fauna Busnardo (1965), the Bulgarian fauna Dimitrova (1967), the north Caucasus and Crimean fauna Drushtchits and Kudryavtseva (1960), the Madagascar fauna Collignon (1962), the Arctic Canadian fauna Jeletzky (1971), Pacific slope of Canadian fauna Jeletzky (1971), the Ono fauna Murphy (1975) and the Boyaca fauna Bürgl (1954). By these references, I confirmed individual species shown by plates and descriptions on the Hannover, Wernsdorfer, Bulgarian, northern Caucasus and Crimean, Madagascar and Ono faunas, whereas I followed the specific names by lists on the Yorkshire, Angles, Arctic and Pacific slope of

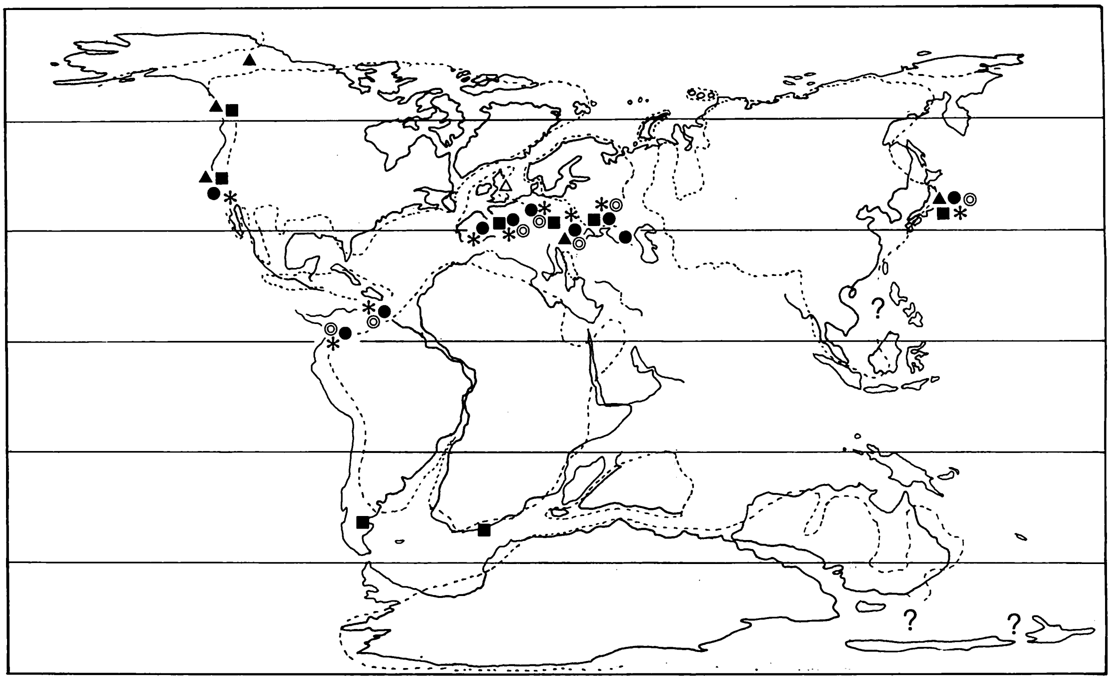


Figure 11. Map showing the distribution of the Barremian ammonite genera: *Shasticrioceras, Heteroceras, Karsteniceras, Barremites* and *Pulchellia,* found also in the Ishido Formation. Presumed land dotted. Continental position after Smith *et al.* (1981). Coastlines from Harrington (1962), Gordon (1973), Jeletzky (1970), Kauffman (1973) and Ziegler (1982).

Canada and Boyaca faunas.

From the geographical distribution of the ammonite faunas in the early Barremian, it is apparent from Table 2 that the majority of the ammonites in the Circum-Pacific localities are of Tethyan affinity. The Arctic Canadian fauna is more characteristic of the Boreal-realm, which includes also northwestern Europe. However, the Pacific slope of Canada and Japan have a fauna in which there are elements of Boreal affinity in a predominantly Tethyan assemblage (Fig. 11).

Conclusions

1. Five genera including six species of ammonites from the Ishido Formation, which were not included in the descriptions by Obata *et al.* (1976) and Obata and Matsukawa (1984), are described in this paper. The total number of the ammonites now known from this formation amounts to 15 species belonging to 10 genera.

2. The ammonite fauna of the Ishido Formation is characterized by two Tethyan genera, *Barremites* and *Heteroceras,* and also by the association of smooth or weakly ornate ammonites and heteromorph ammonites which characterises faunas of this age in the Tethyan province as a whole including those in the southern USSR and the type sequence of Angles, France.

3. The *Simbirskites* species from the lower Ishido Formation is a migrant from the northwest European province via the Arctic region.

4. The ammonite fauna of the Ishido Formation shows a high similarity to the

Californian and Colombian faunas in the Circum Pacific region and to the Silesian and Bulgarian faunas in the Mediterranean region. These faunas from the Circum Pacific region are essentially Tethyan in character. However, the Pacific slope of Canada and Japan have a fauna in which there are elements of Boreal affinity in a predominantly Tethyan assemblage.

Appendix

Collection localities

Loc. SA-101

Location: About 1000 m north of Myoke, Nakazato village, Tano county, Gunma Prefecture.

Horizon and age: Basal part of the Ishido Formation. Early Barremian.

Occurrence: Dark bluish gray sandstone in which a fossiliferous lens of gray calcareous sandstone occurs. Ammonites occur in the lens together with bivalves which were reported by Matsukawa (1983; table 2). A specimen of *Simbirskites* (*Milanowskia*) sp. was collected from this horizon. Although fragmentary, its fine ornament is well preserved. Fossil bivalves are represented by disarticulated broken valves.

Collector: M. Matsukawa.

Loc. SA-200

Location: North of Ichinosebashi, to the north of Sebayashi hamlet, Nakazato village, Tano county, Gunma Prefecture.

Horizon and age: Upper part of the Ishido Formation. Early Barremian.

Occurrence: Bluish gray, poorly stratified muddy sandstone. A fragmentary specimen of *Shasticrioceras* sp. aff. *S. patricki* Murphy was collected from this bed and is not accompanied by other mollusks.

Collector: M. Matsukawa.

Loc. SA-203 [= loc. 9, Oze, in Yabe *et al.* (1926); = loc. N9 in Takei (1963); = Hy4008 in Hayami (1966)]

Location: Ichinosebashi, north of Sebayashi, Nakazato village, Tano county, Gunma Prefecture.

Horizon and age: Uppermost part of the Ishido Formation. Late Barremian.

Occurrence: Dark bluish muddy sandstone consisting of thick-bedded to massive strata, and alternating beds of dark bluish muddy sandstone and shale. Many mollusks were reported from this bed (see table 2 in Matsukawa, 1983). Fossils are represented by casts and molds. In the small specimens (*e.g. Barremites* (*B.*) *strettostoma,* a smooth to weakly ornate ammonite), the body chamber and phragmocone are generally well preserved. In some large-size specimens (*e.g. Pseudohaploceras japonicum,* a weakly ornate ammonite and *Heteroceras* (*H.*) sp. aff. *H.* (*H.*) *astieri,* a heteromorph ammonite), phragmocones and body chambers are separated in most cases. Many bivalves are generally in good preservation with conjoined valves.

Ammonite species: *Calliphylloceras* sp., *Heteroceras* (*H.*) sp. aff. *H.* (*H.*) *astieri, Heteroceras* (*H.*) sp., *Heteroceras (Argvethites)* sp., *Barremites* (*B.*) *strettostoma, Barremites* (*B.*) sp., *Pseudohaploceras japonicum,* Phylloceratidae gen. et sp. indet., Ancyloceratidae gen. et sp. indet., Heteroceratidae gen. et sp. indet. and Ptychoceratidae gen. et sp. indet.

Collectors: H. Tsuda, Y. Ogawa, M. Futakami, and M. Matsukawa.

Loc. SA-307 [≒ loc. 10, Kawarazawa, in Yabe *et al.* (1926)]

Location: Niheizawa, being located at about 1 km north of Sakamoto hamlet, Oganomachi town, Chichibu county, Saitama Prefecture.

Horizon and age: Upper part of the Ishido Formation. Late Barremian.

Occurrence: Dark blue, calcareous, thick-bedded and fine-grained sandstone with intercalated thin-bedded muddy sandstone. Many mollusks were reported by Matsukawa (1983, table 2). The mode of occurrence and preservation of bivalves differ generally depending on the type of lithology. Casts and molds, and disjoint shells that are not completely broken, are contained in the thick-bedded, fine-grained sandstone; fine well preserved ornament, and articulated valves are found in the thinly-bedded muddy sandstone. Fine spines of many *Ceratosiphon* sp. (gastropods) are also well preserved in the thinly-bedded muddy sandstone. As far as the ammonites are concerned, the ribs on the main helical whorl of *Heteroceras* (*H.*) sp. aff. *H.* (*H.*) *astieri* from the thick-bedded fine-grained sandstone are well preserved. However, the fine ornament of *Barremites* (*B.*) sp. collected from the thinly-bedded muddy sandstone is fairly crushed toward the lateral margin.

Ammonite species: *Heteroceras* (*H.*) sp. aff. *H.* (*H.*) *astieri, Barremites* (*B.*) sp. and *Valdedorsella* (*Puezalpella*) sp.

Collector: M. Matsukawa.

Loc. SA-416

Location: Tonedaira, Ueno village, Tano county, Gunma Prefecture.

Horizon and age: Upper part of the Ishido Formation. Late Barremian.

Occurrence: Thick-bedded black muddy sandstone. A single specimen of *Barremites* (*B.*) *strettostoma* was collected. It is partly erased and is not accompanied by other mollusks.

Collector: M. Matsukawa.

Loc. SA-604

Location: Sinzaburomaezawa located about 2 km west of Jukkoku pass, Saku town, Minamisaku county, Nagano Prefecture.

Horizon and age: Upper part of the Ishido Formation. Late Barremian.

Occurrence: Black muddy sandstone. A specimen of *Heteroceras* (*H.*) sp. was collected and is a fragment of curved shaft with well preserved fine ornament. *Pholadomya* sp. is also present in the same bed preserved as disarticulated valves.

Collector: M. Matsukawa.

Loc. SA-621 [= loc. 4, Ishido, in Yabe *et al.* (1926); = loc. Hy 4015 in Hayami (1966); = loc. 11 in Takei *et al.* (1977)]

Location: Ishido, about 4 km east of Koya, Saku town, Minamisaku county, Nagano Prefecture.

Horizon and age: Lower part of the Ishido Formation. Early Barremian.

Occurrence: Thick-bedded black muddy sandstone. Mollusks are occasionally found in the muddy sandstone to the exclusion of other fossils. Many mollusks were reported from the bed: Yabe *et al.* (1926), Hayami (1965, 66), Takei *et al.* (1977) and Matsukawa (1983). Ammonite specimens collected are represented by casts and molds. Their body chambers and phragmocones are generally preserved, although the inner whorl of the younger stages of many specimens are flattened laterally. Bivalves are characterized by small specimens. These specimens are mostly preserved as disjointed valves, although the fine ornament is well preserved. Fine spines of gastropods are preserved intact as casts.

Ammonite species: *Karsteniceras asiaticum, K. obatai, Simbirskites* (*Milanowskia*) sp., *Barremites* (*B.*) *difficilis, Pulchellia ishidoensis* and Ancyloceratidae gen. et sp. indet.

Collectors: K. Tanaka, H. Kumai, S. Usuda, I. Fujiyama and M. Matsukawa.

Loc. SA-632 [≒ loc. 18 in Takei *et al.* (1977)]

Location: The upper stream of Miyakozawa, about 2.5 km south of Koya, Saku town, Minamisaku county, Nagano Prefecture.

Horizon and age: Uppermost part of the Ishido Formation. Late Barremian.

Occurrence: Black muddy, bedded-sandstone. A single poorly preserved ammonite specimen, here identified as Ancyloceratidae gen. et sp. indet was collected from this bed. The specimen is flattened laterally, without the inner whorls of younger stages. Some bivalves, *Nanonavis* (*N.*) *yokoyamai* and *Astarte* (*A.*) *subsenecta,* occur in the same layer as disarticulated valves.

Collector: M. Matsukawa.

Loc. SA-802

Location: Mamyodaira, Oganomachi town, Chichibu county, Saitama Prefecture.

Horizon and age: Upper part of the Ishido Formation. Late Barremian.

Occurrence: Greenish, medium-grained sandstone, in which a lens of fossiliferous black calcareous mudstone occurs with well preserved ammonite specimens. Bivalves with fine ornament are also well preserved, although they occur mostly as disjointed valves.

Ammonite species: *Barremites* (*B.*) *strettostoma.*

Collector: T. Kinoshita.

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本邦石堂層産のバレミアン期アンモナイト——追加と動物群の解析：山中地域のバレミアン石堂層から産出したアンモナイト５属６種を記載した。これにより，本層から産出したアンモナイトの10属15種の記載を終了した。本層のアンモナイト動物群は，主に平滑型と異常巻の二つの形態型のものにより構成される。これは，同時代のソ連南部とフランスの模式地のそれと同様で，この時代のアンモナイト動物群の形態型構成の特徴を示している。この動物群は，*Barremites* と*Heteroceras*を含み，テチス動物区の地中海地域の動物群と高い類似性を示す。また，この動物群には *Simbirskites* (*Milanowskia*) の一種が含まれるが，これはヨーロッパのボレアル地域から北極海を経て移動してきたものであると推定される。 松川正樹

Trans. Proc. Palaeont. Soc. Japan, N.S., No. 149, pp. 417–429, April 30, 1988

855. PLIOCENE FRESHWATER BIVALVES (*LAMPROTULA* AND *CUNEOPSIS*: UNIONIDAE) FROM THE IGA FORMATION, MIE PREFECTURE, CENTRAL JAPAN*

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Abstract. The following six species of freshwater bivalves are described from the Pliocene Iga Formation in the Ueno Basin, central Japan: *Lamprotula* (*Sinolamprotula*) sp. A, *L.* (*Parunio*) sp. B, *L.* sp., *Cuneopsis* (*Cuneopsis*) *gracilenta*, n. sp., *C.* (*Procuneopsis*) *okuyamai*, n. sp., and *C.* (*Tchangsinaia*) *praemaxima*, n. sp. These unionid species of the genera *Lamprotula* and *Cuneopsis* become extinct in the Japanese Islands in Recent times, but they are still living in China. These bivalves are the only record of this age known from the Japanese Islands.

Introduction

The freshwater fossil flora and fauna from the Iga Formation of the Kobiwako Group are quite unique among the Pliocene fossil biota of Japan (Okuyama, 1981b, c, 1983–1986; Nakajima *et al.*, 1983; Matsuoka, 1985a, 1987; Tanaka and Matsuoka, 1985; Nakajima, 1986). Matsuoka (1985a) proposed a name of the Iga non-marine fauna for freshwater fossils from the Iga Formation in the eastern part of the Ueno Basin, Mie Prefecture.

Both of Iga non-marine molluscan fauna I and II (Matsuoka, 1987) belonging to the Iga non-marine fauna differ from the Miocene Sasebo non-marine molluscan fauna (Suzuki, 1941) and other Pleistocene non-marine molluscan faunas (Matsuoka and Nakamura, 1981; Matsuoka, 1983, 1986, 1987) in the faunal compositions. The Iga non-marine molluscan faunas consist of some 20 species including many new species. Among them, one new genus and four new species of the viviparid and pleurocerid have been already described (Matsuoka, 1985b).

In this paper, *Lamprotula* (*Sinolamprotula*) sp. A, *L.* (*Parunio*) sp. B, *L.* sp., *Cuneopsis* (*Cuneopsis*) *gracilenta*, n. sp., *C.* (*Procuneopsis*) *okuyamai*, n. sp., and *C.* (*Tchangsinaia*) *praemaxima*, n. sp. are described and figured. This is one of a series of papers dealing with invertebrate fossils from the Kobiwako Group.

*Received October 21, 1987; Revised manuscript accepted March 18, 1988.

Geology and localities

The Iga Formation is distributed mainly in the Ueno (Iga) Basin. Fossiliferous sequences of the non-marine Iga Formation are well exposed in the Ohyamada area in the eastern part of the basin. Stratigraphic studies of the Iga Formation were made by Takaya (1963), Kondo (1968), Okuyama (1981a), and Yokoyama *et al.* (1980). The Iga Formation consists mainly of silt, sand, and gravel, and intercalates many volcanic ash layers. It is divided into three lithological units in ascending order: Ohyamada Clays, Kashikimura Sands, and Aitagawa Alternations. The Ohyamada Clays yield abundant diatoms, sponges, molluscs, fishes, and other fossils. The fossil molluscs described in this paper were obtained from six localities of the Ohyamada Clays (Figure 1). The Hattorigawa volcanic ash layer in the lower part of the Ohyamada Clays

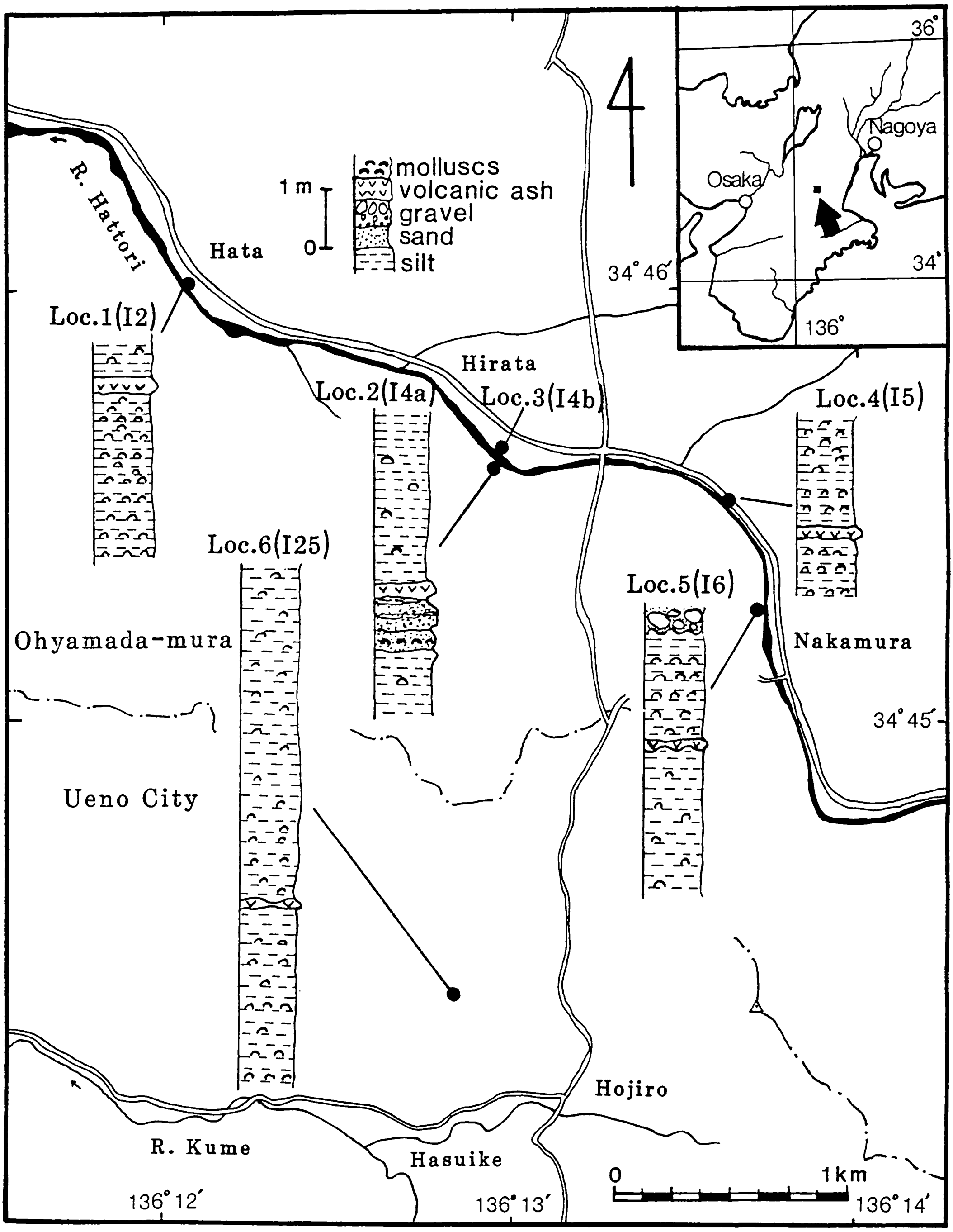


Figure 1. Locations of six geologic sections where fossil molluscs were collected.

was dated 4.6 Ma by the fission track method (Yokoyama *et al.*, 1980).

Locality 1(I2): A riverbed on the north side of the Hattori River at Hata, Ohyamada-mura, Ayama-gun (lat. 34°46'N, long. 136°12'7"E).

A gray silt exposed on the riverbed of the Hattori River includes two volcanic ash layers: Hattorigawa I and II, and yields wood, leaves, diatoms, protozoans, sponges, molluscs, fishes, and reptiles. The fossil molluscs were collected from a gray silt about 1 to 2 m below the Hattorigawa II volcanic ash layer. The molluscan assemblage consists of *Igapaludina stricta, Anodonta* (*Pleioanodonta*) sp., *Semisulcospira* (*Biwamelania*) *praemultigranosa, Bellamya suzukii, Psilunio* sp., *Acuticosta* sp., *Lamprotula* sp., *Cuneopsis gracilenta,* n. sp., *C. okuyamai,* n. sp., *Unio* (*Nodularia*) sp., *Inversidens* sp., and *Lepidodesma* sp.

From this locality, Okuyama (1981b, c, 1983–1986) collected and illustrated many fossils such as macroscopic plants, molluscs, cyprinid fishes, turtles, and crocodiles. Kobayakawa and Okuyama (1984) reported a silulid fish, *Silurus* sp.

Locality 2 (I4a): A riverbed on the south side of the Hattori River, Hirata, Ohyamada-mura, Ayama-gun (lat. 34°45'35"N, long. 136°12'59" E).

A silty sand below 5 to 16 cm thick volcanic ash layer yields the following species, *Igapaludina stricta, Semisulcospira* (*Biwamelania*) *praemultigranosa, S.* (*B.*) sp., *Lepidodesma* sp., *Unio* (*Nodularia*) sp., *Inversidens* sp., *Acuticosta* sp., *Cuneopsis gracilenta*, n. sp., and *Lamprotula* (*Sinolamprotula*) sp. A. They are preserved as molds in silty sand including coarse grains of quartz and plant fragments.

Locality 3 (I4b): A riverbed on the north side of the Hattori River, Hirata, Ohyamada-mura, Ayama-gun.

This locality is on the opposite side of the Locality 2. The following well-preserved molluscs from silt blocks, which had been derived from upstream outcrops of the Hattori River, were collected by Okuyama: *Igapaludina stricta, Lamprotula* (*Parunio*) sp. B, *Acuticosta* sp., *Anodonta* (*Pleioanodonta*) sp., *Psilunio* sp., *Cuneopsis okuyamai,* n. sp., *C. praemaxima,* n. sp., *C. gracilenta,* n. sp., *Unio* (*Nodularia*) sp., *Lepidodesma* sp., and *Inversidens* sp. The horizon of the fossiliferous bed is probably a few meters above the Nakamura volcanic ash layer.

Locality 4 (I5): An exposure on the north side of the Hattori River, about 1 km southeast of Hirata, Ohyamadamura, Ayama-gun (lat. 34° 45'29"N, long. 136°13'37"E).

A gray silt exposed on the riverbed yields abundant sponges, molluscs, and fishes. The molluscan assemblage consists of *Igapaludina stricta, Semisulcospira* (*Biwamelania*) *praemultigranosa, Cuneopsis okuyamai,* n. sp., *C. gracilenta,* n. sp., and *Inversidens* sp. An interbedded volcanic ash layer with the fossiliferous bed is situated stratigraphically several meters above the Nakamura volcanic ash layer.

Locality 5 (I6): A riverbed on the west side of the Hattori River, Nakamura, Ohyamada-mura, Ayama-gun (lat. 34°45'19"N, long. 136°13'44" E).

A fossiliferous silt bed is exposed on the riverbed. *Igapaludina stricta, Bellamya suzukii, Semisulcospira* (*Biwamelania*) *praemultigranosa, Cuneopsis okuyamai,* n. sp., *C. gracilenta,* n. sp., *Inversidens* sp., and *Acuticosta* sp. were obtained from a gray silt about 1 m above the Nakamura volcanic ash layer. The volcanic ash is intercalated in the lower part of the Ohyamada Clays.

From this locality, the following fossils have been recorded: diatoms (Tomoda and Negoro, 1979; Negoro, 1981; Tanaka and Matsuoka, 1985), and fishes (Nakajima *et al.*, 1983; Nakajima, 1984).

Locality 6 (I25): A cliff about 500 m north of Hasuike, Ueno City (lat. 34°44'23"N, long. 136° 12'51"E).

A gray silt exposed in this cliff yields wood fragments, sponges, molluscs, and fishes, and includes one volcanic ash layer. There occur such well-preserved molluscan fossils as *Igapaludina stricta, Semisulcospira* (*Biwamelania*) *praemultigranosa, Cuneopsis praemaxima,* n. sp., *Inversidens* sp., and *Anodonta* (*Pleioanodonta*) sp. The volcanic ash layer is probably correlated with the Hattorigawa II volcanic ash.

Systematic paleontology

All the illustrated specimens are deposited in the collection of Department of Earth Sciences, Nagoya University, Nagoya (ESN) and in the Mizunami Fossil Museum, Gifu (MFM).

Class Bivalvia

Family Unionidae Fleming, 1828

Genus *Lamprotula* Simpson, 1900

Type species:– *Chama plumbea* Chemnitz, by original designation. Recent. Southeast Asia.

Geologic range:– Jurassic to Recent.

Discussion:–The genus *Lamprotula* was originally proposed as a subgenus of *Quadrula* Rafinesque, 1820 by Simpson (1900). The monograph "Fossil Lamellibranchia of China," published in 1976 by Nanjing Institute of Geology and Palaeontology, divided the genus *Lamprotula* into nine subgenera including two new subgenera: *Lamprotula* (s. str.) Simpson, 1900; *Eolamprotula* Ku, 1962; *Sinolamprotula* Gu et Huang, 1976; *Odhnerella* Modell, 1964; *Sulcatula* Leroy, 1940; *Cuneolamprotula* Ku et Huang, 1976; *Paruino* Ping 1930; *Scriptolamprotula* Modell, 1964.

Recent species of the present genus distributed in Korea, China, and Vietnam.

Subgenus *Sinolamprotula* Gu et Huang, 1976

Type species:– *Unio leai* Gray, 1836, by original designation. Recent. Vietnam, China, and Korea.

Geologic range:–Pliocene to Recent.

Discussion:–The subgenus *Sinolamprotula* was proposed as a replacement name of *Richthofenia* Modell, 1964 by Gu and Huang (1976). This name is equivalent to Simpson's (1900) *Quadrula leai* group. The juvenile shell is similar to that of the genus *Inversidens* (Modell, 1964).

Fossils of the subgenus *Sinolamprotula* have been reported only from China as follows: *Lamprotula* (*S.*) *leai* (Gray), Early Pleistocene Sanmen Formation in Sanmenxia, Hunan Province and Early Pleistocene Nihowan Formation in Sanggan He, Hubei Province (Wan, 1961), Latest Pleistocene Zhenpiyan Cave Deposits in Guilin, Guangxi Province (Huang, 1981), and *Lamprotula* (*S.*) *obovata* Huang from the Latest Zhenpiyan Cave Deposits in Guilin, Guangxi Province (Huang, 1981).

Lamprotula (*Sinolamprotula*) sp. A

Figures 2, 4-3

1985 *Lamprotula* sp., Matsuoka, *Monogr. Assoc. Geol. Coll. Japan*, No. 29, p. 79.

Material studied:–ESN-40101

Description and discussion:–This description is based on inner and outer molds of one left valve. The ventral and posterior margins of the inner mold are distorted, but it preserves its characteristic shape, hinge and muscle scars of the subgenus *Sinolamprotula*.

Shell rhomboidal, attaining 54.5 mm in length, and moderately inflated. Beak low, located at anterior part of shell. Dentition imperfectly known; left valve possessing two pseudocardinal teeth, two lateral teeth, and narrow interdentum. Dorsal pseudocardinal tooth stout, compressed trianguloid, and ventral one feeble with a wide socket. Lateral teeth weakly curved, subparallel to shell axis. Angle formed between pseudocardinal tooth and lateral

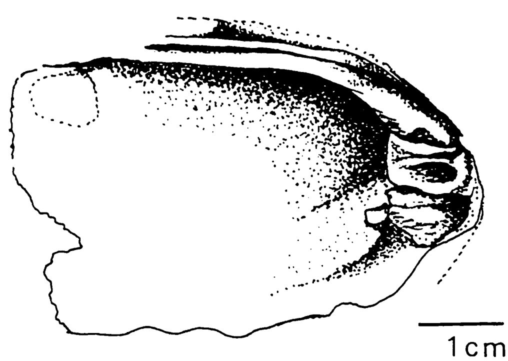


Figure 2. Inner surface of *Lamprotula* (*Sinolamprotula*) sp. A.

one measuring 17 degrees. Anterior adductor muscular scar deep, subtrianguloid, and attaining 8.4 mm in maximum diameter. Pedal protractor muscle scar adjoined posteriorly adductor scar, and reaching 3.3 mm in maximum diameter. Pallial line indistinct.

Hinge and muscular scars of this species resemble those of the Recent *Lamprotula* (*S.*) *leai* (Gray).

Stratigraphic range:—Restricted to the Ohyamada Clays, Iga Formation.

Occurrence:—Locality 2 (I4a).

Subgenus *Parunio* Ping, 1931

Type species:—*Parunio crassus* Ping (=*Lamprotula antiqua* Odhner), by original designation. Pliocene. Tungur, Mongolia.

Geologic range:—Oligo-Miocene to Recent.

Discussion:—Those Oligocene to Miocene species identified under the subgenus *Parunio* have been reported from the Tanhoi Formation, southern district of Lake Baikal (Popova, 1981), northwestern district of Lake Barun-Torei, Siberia (Popova *et al.*, 1974), Nojima Group, Nagasaki, southwest Japan (Ueji, 1934), and Koura Formation, Shimane, southwest Japan (Matsuoka, 1985a). For the Pliocene, two records come from Mongolia (Ping, 1931) and Japan (in this paper). Those species from Pleistocene sediments, as well as the Recent species of this subgenus, are limited to the eastern district of China (Odhner, 1925; Leroy, 1940; Otuka, 1940; Chow, 1958; Wan, 1961).

Lamprotula (*Parunio*) sp. B

Figures 3; 4-1a, b

1985 *Lamprotula* (*Parunio*) sp., Matsuoka, *Monogr. Assoc. Geol. Coll. Japan*, No. 29, p. 79.

Material studied:— ESN-40084

Description:—Shell ovate, medium in size, thick, somewhat inflated. Postero-dorsal margin slightly curved, forming a somewhat sharp angle with inclined ventral margin. Anterior margin narrow, slightly truncated. Hinge ligament conspicuous, located posteriorly to beaks, reaching 29 mm in length. Posterior ridge inconspicuous. Beaks prominent, oblique, and situated in anterior part of shell. Dentition imperfectly known; left valve bearing at least two pseudocardinal teeth; dorsal one large and long, ventral one short; lateral one unknown. Hinge plate wide. Beak cavities moderately deep, possessing several muscle scars. Anterior adductor muscle scar subtriangle, deep, irregular with serrate-surface, attaining 8.8 mm in maximum length, and pedal protractor muscle scar located within muscle scar, elliptical, deep, and reaching 2.6 mm in maximum length. Anterior pedal retractor muscle scar situated below lower pseudocardinal tooth, elongated, and measuring 2.7 mm in maximum length. Surface of shell shiny bearing irregularly undulated concentric with pustules.

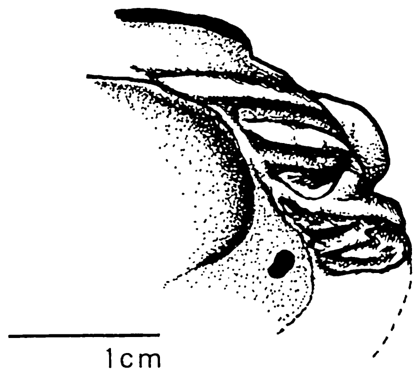
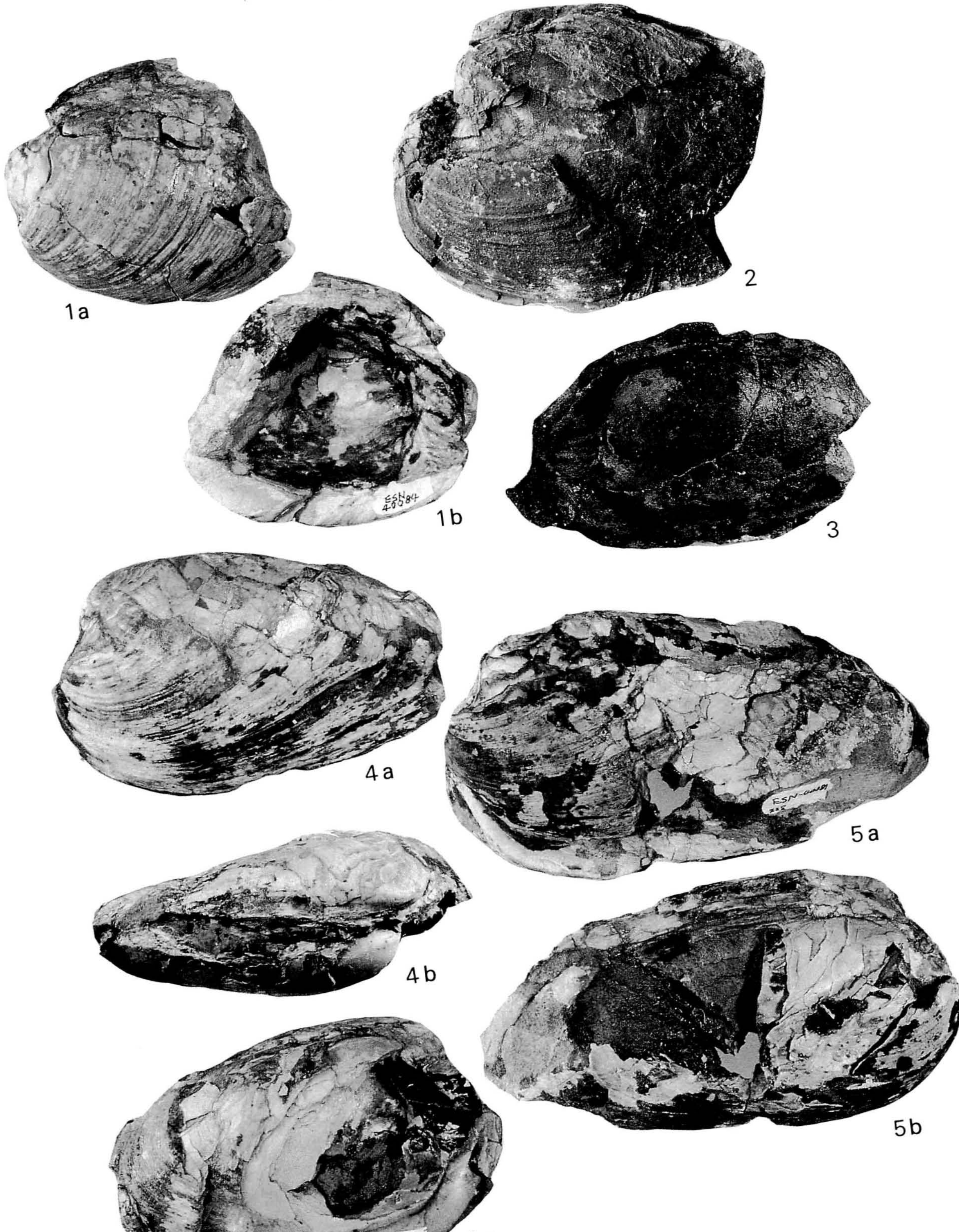


Figure 3. Inner surface of *Lamprotula* (*Parunio*) sp. B.

Discussion:—Obtained shell is a pair of imperfect attached valves measuring 44.7 mm in length and 43.5 mm in width. This is the first record of this subgenus from the Pliocene strata in Japan.

The shape of *Lamprotula* (*Parunio*) sp. B has a similarity to *L. nojimensis*, which has been described by Ueji (1934) from the Miocene Nojima Group, Nagasaki, southwest Japan. The present Pliocene species is more ovate in outline with a curved dorsal margin and pustulated sculpture. On the shell surface *Lamprotula* (*Parunio*) sp. B is distinguished the shell surface from *L. antiqua* Odhner by its ventral margin and beak sculpture. The latter species from the Early


1a
2
1b
ESN 40084
3
4a
5a
4b
5b
4c
MFM 110018

Pleistocene Sanmen Formation in Sanxi Province, China has a more rounded ventral margin and well-developed beak sculpture. This species resembles *L. wangi* from the Pleistocene of Sanxi Province, China with respect to its shell outline, but the former lacks the undulated sculpture on the shell surface and possesses angular posterior end.

Stratigraphic range:—Ohyamada Clays of Iga Formation.

Occurrence:—Locality 1 (I2).

Lamprotula sp.

Figure 4-2

Discussion:—Two incomplete specimens (ESN-40136, MFM-111207) of *Lamprotula* which do not appear to belong to any of the above-listed species were collected from the Ohyamada Clays.

Stratigraphic range:—Ohyamada Clays of Iga Formation.

Occurrence:—Locality 1 (I2).

Genus *Cuneopsis* Simpson, 1900

Type species:—*Unio celtiformis* Heude, by original designation. Recent. Jiangxi and Hunan Province, China.

Geologic range:—Jurassic to Recent.

Discussion:—Modell (1964) divided the genus *Cuneopsis* into three types on the basis of shell outline: long-knife type (including *Cuneopsis celtiformis*), long-tongue type (including *C. pisciculus*), and wedge type (including *C. heudei*). Starobogatov (1970) created three subgenera, *Cuneopsis* s. str., *Tchangsinaia*, and *Procuneopsis*, which correspond to the three types described by Modell (1964), respectively.

Five Recent species of this genus are known from central China and north Vietnam (Haas, 1969). In Japan, the geological distribution of the genus *Cuneopsis* ranges from Miocene to Pliocene (Mizuno, 1966 and Matsuoka, 1985a).

Subgenus *Cuneopsis* s. str.

This subgenus is similar to the genus *Lanceolaria* in its shell outline. *Lanceolaria* is more inequilateral, and its posterior and is angular.

The fossil species which can be included in the subgenus *Cuneopsis* are as follows: *Cuneopsis zhenpiyanensis* and *C. subceltiformis* from the latest Pleistocene Zhenpiyan Cave Deposits in Guangxi Province, China (Huang, 1981), *C. nagahamai* from Fukazuki Formation of the Nojima Group, Kurosaki, Kitamatsuura-gun, Nagasaki Prefecture, Japan (Mizuno, 1966), and *C. wershutskyi* from the Oligo-Miocene Tanhoi Formation to the south of Lake Baikal, U.S.S.R. (Popova, 1981).

Cuneopsis (*Cuneopsis*) *gracilenta*, n. sp.

Figures 5-1–4

1985 *Cuneopsis gracilenta*, Matsuoka, *Monogr. Assoc. Geol. Coll. Japan*, No. 29, p. 79 (nomen nudum).

Type locality:—Hata (locality 1 (I2)), Ohyamada-mura, Ayama-gun, Mie Prefecture.

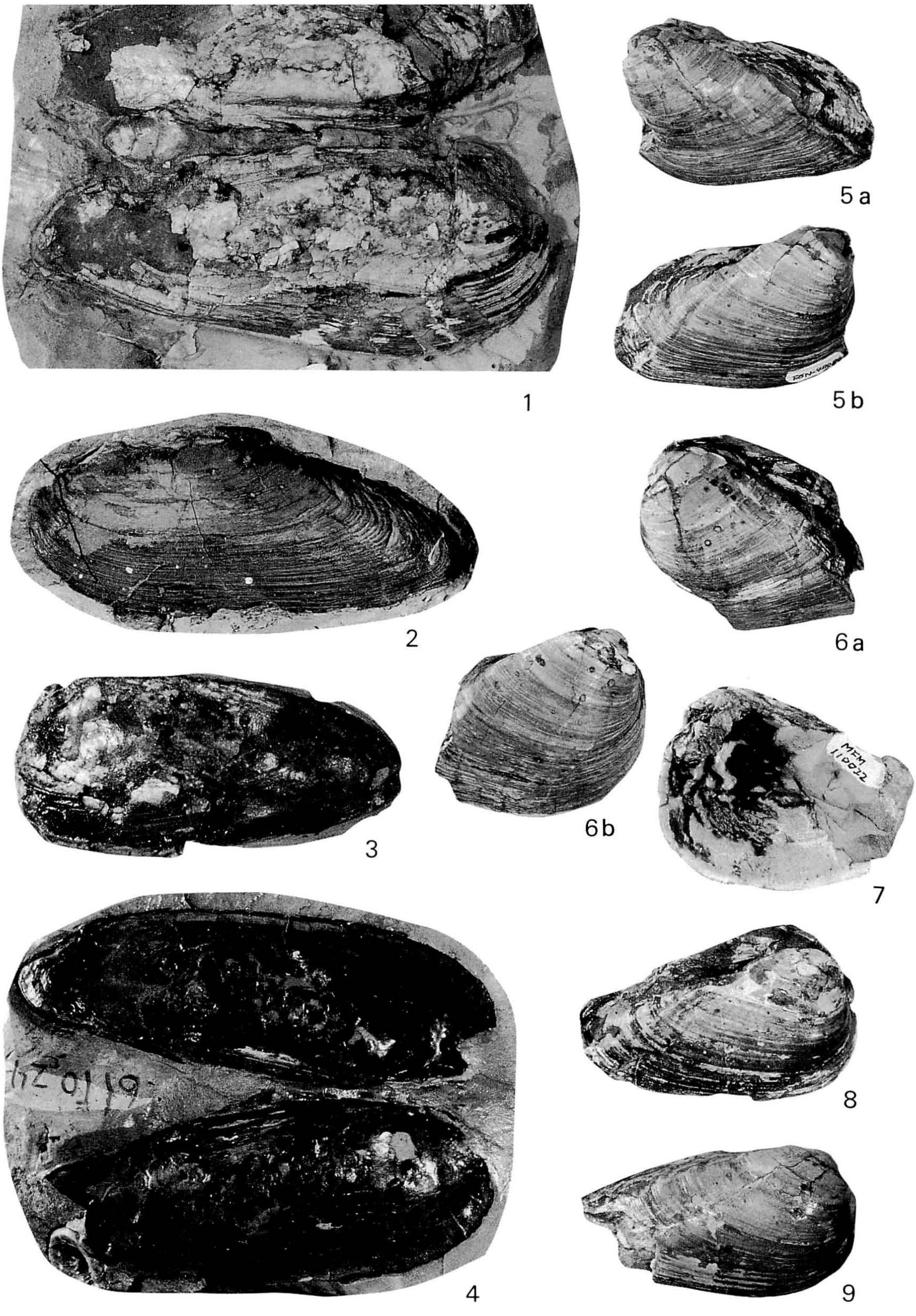
Derivation of name:—*gracilentus*, Latin for slender.

Material studied:—ESN-40097-40099, 40117, 40139, MFM-110026, 110027, 111066-111068, 111090, 111091, 111204, 111205.

Diagnosis:—Beaks located anteriorly at one fifth the length of shell. Length about three times the height. Anterior margin narrowly rounded, truncated above the medial line.

Description:—Shell medium, reaching 86 mm in length. Outline elongated trapezoid, about lance-head shaped, width being three times as long as height. Valves compressed, thickened

← **Figure 4.** All figures are x 1. 1a, b. *Lamprotula* (*Parunio*) sp. B. ESN-40084, left valve; a, outer surface; b, inner surface. 2. *Lamprotula* sp. ESN-40136, attached valves. 3. *Lamprotula* (*Sinolamprotula*) sp. A. ESN-40101, inner mold of left valve. 4a–c. *Cuneopsis* (*Tchangsinaia*) *praemaxima*, n. sp. MFM-110018 (paratype 1), attached valves; a, left side; b, dorsal side; c, right side. 5a, b. *Cuneopsis* (*Tchangsinaia*) *praemaxima*, n. sp. ESN-40081 (holotype), attached valves; a, left side; b, right side. ESN-40084, 40136, and MFM-110018 were collected by Okuyama.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6 a
6 b
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anteriority, inequilateral. Dorsal margin long, straight, sloping downward. Posterior margin narrowly rounded, forming a broad angle with the obliquely descending posterior margin. Ventral margin almost straight, sometimes moderately convex medially. Anterior margin slightly truncated. External ligament distinct, long, located posteriorly of beaks. Posterior ridge conspicuous, bluntly pointed. Posterior slope, narrow, compressed. Beaks low, elevated above the hinge line, situated anteriorly at one fifth the shell length. Surface of shell marked only with concentric lines of growth. Right valve with one pseudocardinal tooth, compressed triangular, no interdentum, and one lateral tooth; left valve with two compressed pseudocardinal teeth, its anterior one large, and two lateral teeth, ventral one distinct. Beak cavities shallow. Anterior adductor muscle scar deep, trianguloid; posterior muscle scar subcircular, anterior side distinct; pedal protractor located in the front of the anterior adductor muscle scar, orbiculoid, distinct. Pallial line distinct anteriorly in particular.

Discussion:—In its general shape, *Cuneopsis gracilenta* is similar to *Cuneopsis celtiformis* (Heude) distributed in Jiangxi and Hunan Provinces of China (Heude, 1874), *C. subceltiformis* Huang and *C. zhenpiyanensis* Huang, both from the latest Pleistocene of the Zhenpiyan Cave Deposits in Guangxi Province of China (Huang, 1981), *C. nagahamai* from the Miocene Nojima Group, Nagasaki, southwest Japan (Mizuno, 1966). This new species is distinguished from four other species by the shapes of posterior margin, beak, and hinge plate.

Measurements (in mm):—

	Length	Height
ESN-40117 (holotype)	84.2	32.0
ESN-40097 (paratype 1)	70.3	26.0
ESN-40099 (paratype 2)	75.1	30.3
MFM-110026 (paratype 3)	64.8	26.4
MFM-110027 (paratype 4)	56.2	24.2
MFM-110036 (paratype 5)	61.5	27.3
MFM-111067	86.4	29.8
MFM-111091	68.0	24.4
MFM-111090	77 +	31.9
ESN-40098	68.7	27 +
MFM-111068	62.2	23.2

Stratigraphic range:—Iga Formation to Koka Formation (Matsuoka, 1987).

Occurrence:—Localities 1 (I2), 4 (I5), and 5 (I6).

Subgenus *Procuneopsis* Starobogatov, 1970

Type species:—*Unio heudei* Heude, 1874 by original designation. Recent. Hebei, Shandong, Zhejiang, Jiangsu, Anhui, Jiangxi, Hubei, and Hunan Provinces in central China.

Discussion:—Ten species from U.S.S.R. are included in *Cuneopsis* (*Procuneopsis*) by Popova (1981). This subgenus also contains probably Cenozoic species, *C. barbouri* King, 1926, *C. heudei nihowanensis* Otuka, 1942, *C. shanghaiensis* Huang et Lan, 1976, *C. crassata* Huang et Wei, 1976, and *C. subovata* Huang et Wei, 1976. The latter four have been reported from China (Nanjing Inst. Geol. and Palaeont., 1976). The geographical distribution of *Procuneopsis* in the Eocene to Pliocene interval is restricted to Siberia (north China, Mongolia, south Baikal, and south Primorskij).

Cuneopsis (*Procuneopsis*) *okuyamai*, n. sp.

Figures 5-5a, b, 6a, b, 7–9

1985 *Cuneopsis okuyamai*, Matsuoka, *Monogr. Assoc. Geol. Coll. Japan*, No. 29, p. 79 (nomen nudum).

Type locality: – Hirata, Ohyamada-mura, Ayama-gun, Mie Prefecture.

← **Figure 5.** All figures are × 1. 1–4. *Cuneopsis* (*Cuneopsis*) *gracilenta*, n. sp. 1, ESN-40117 (holotype). 2, ESN-40097 (paratype 1), Right valve, outer mold. 3, MFM-110036 (paratype 5), Left valve. 4, ESN-40139, inner mold. 5–9. *Cuneopsis* (*Procuneopsis*) *okuyamai*, n. sp. 5a–b, ESN-40086 (holotype), attached valves. 6a–b, MFM-110021 (paratype 2). 7, MFM-110022 (paratype 3), inner surface of right valve. 8, ESN-40137, attached valves. 9, ESN-40138, attached valves. ESN-40086, 40097, 40117, 40137-40139, MFM-110021, 110022, and 110036 were collected by Okuyama.

Derivation of name:—Named in honor of Mr. Shigemi Okuyama who expended great efforts in collecting molluscs from the Iga Formation.

Material studied:—ESN-40086-40090, 40137, 40138, MFM-110021, 110022, 111059–111061, 111092–111094, 111206.

Diagnosis:—Shell medium, subangular. Beaks situated at extreme end of antero-dorsal margin. Posterior margin medially pointed. Ventral margin straight.

Description:—Shell subtriangular, medium, reaching 50 mm in length. Valves subinflated, especially inflated in area below beaks, solid, inequilateral. Dorsal margin slightly convex. Posterior margin medially pointed. Ventral margin straight, with moderate slope in anterior part. Anterior margin broadly rounded or slightly truncated. Hinge ligament short and inconspicuous, located posteriorly of beaks. Posterior ridges fairly well defined near beaks, becoming faint toward posterior margin. Posterior slope slightly concave. Beaks full, oblique, elevated above hinge line, located near anterior end of shell, their sculpture consisting of a few weak radial ridges. Surface of shell generally smooth with fine growth lines. Right valve with one compressed, triangular, and serrated pseudocardinal tooth; no interdentum; almost straight, long, main lateral tooth, and another short tooth in postero-ventral hinge plate. Left valve with two compressed pseudocardinal teeth and probably two lateral teeth. Beak cavities moderately deep. Anterior adductor muscle scar deep, semicircular. Anterior pedal retractor muscle scar rough, distinct, small, located in front of anterior adductor one. Pedal protractor muscle scar under the hinge plate. Posterior adductor muscle scar subquadrangular, smooth, defined, especially anterior side. Posterior pedal retractor muscle scar deep, small, trapezoid, located under posterior end of lateral tooth. Pallial line distinct anteriorly.

Discussion:—*Cuneopsis okuyamai* is very similar to the Recent species *Cuneopsis capitata* which is distributed in Anhui, Zhejiang, Jiangsu, Jiangxi, Hubei, and Hunan Provinces of central China. The present new species differs from the Recent in having a narrow hinge plate and straight ventral margin having a wider hinge plate and concaved ventral margin. *Cuneopsis shanghaiensis* from the Quaternary of Shanghai, Jiangsu Province, China differs from *Cuneopsis okuyamai*, in possessing major ridges on the shell surface and a concaved ventral margin. Those specimens figured by Huang (1964) as *Cuneopsis martinsoni* from the Tanhoi Formation to the south of Lake Baikal is closely related to this new species. However, the posterior margin of the latter species is moderately pointed, and the ventral margin is straight.

Measurements (in mm):—

	Length	Height	Width
ESN-40086 (holotype)	40.0	26.6	19.8
ESN-40087 (paratype 1)	45.0	27.0	20.3
MFM-110021 (paratype 2)	34 +	31.7	21.8
MFM-110022 (paratype 3)	39.5	30.3	12.2
MFM-111059	48.2	24.7	14.6
ESN-40088	44 +	22.0	–
MFM-111094	34.7	24.4	15 +
ESN-40085	14.8	13.1	–

Stratigraphic range:—Ohyamada Clays to Aitagawa Alternations of Iga Formation.

Occurrence:—Localities 1(I2), 3(I4b), and 5(I6).

Subgenus *Tchangsinaia* Starobogatov, 1970

Type species:—*Unio pisciculus* Heude, by original designation. Recent. Jiangsu, Anhui, Zhejiang, Jiangxi, Hubei, and Hunan Provinces in central China.

Discussion:—Among Neogene bivalves of the Kyzylgir Formation in the Chujskaya Basin, Altai Highlands, Popova (1981) assigned three species to the present subgenus, namely *Cuneopsis tuerykensis* Popova et Star, *C. elongata* Kursal, and *C. pliocaenica* Kursal. *Cuneopsis teilhardi* Leroy, 1940 and *C. maxima* Odhner, 1925 from the Tertiary of China are herein included in this subgenus. Among the Recent species of *Cuneopsis*, only *C. piscicula* belongs to the present subgenus.

Cuneopsis (*Tchangsinaia*) *praemaxima*, n. sp.

Figures 4-4a–c, 5a–b

1985 *Cuneopsis praemaxima*, Matsuoka, *Monogr. Assoc. Geol. Coll. Japan*, No. 29, p. 79 (nomen nudum).

Type locality:—Hojiro (locality 6(I25)), Ueno City, Mie Prefecture.

Derivation of name:—*Prae-*, Latin for before, + *maxima*, Latin for large.

Material studied:—ESN-40081 and MFM-110018.

Diagnosis:—Shell medium, comparatively solid, elliptical. Length about two times larger than height. Beaks situated anteriorly at one seventh to one eighth the shell length. Dorsal margin moderately curved. Hinge ligament occupied about half of dorsal margin.

Description:—Shell medium, reaching 79 mm in length, elliptical, asymmetric about two times as long as height. Commissure of plane dextrally twisted. Left valve overhanging right valve. Valves inequilateral comparatively solid, especially anterior part compressed, inflated in area below beaks. Dorsal margin regularly and slightly convex. Posterior margin broadly rounded or somewhat truncated. Ventral margin slightly curved, with concave middle part, and resuming the same curvative up to anterior margin. Anterior margin broadly rounded. Hinge ligament conspicuous, long, nearly half the length of dorsal margin, located posteriorly of beaks. Posterior ridge bluntly rounded. Posterior slope, narrow, straight or concave. Beaks full, prosogyrate, eroded, somewhat elevated above hinge line, and located anteriorly at one seventh to one eighth the shell length. Surface of shell bearing only concentric lines of growth. Dentition partially known; left valve with one stout pseudocardinal tooth; right valve possessing at least one pesudocardinal tooth, and a long and slender lateral tooth. Beak cavities shallow. Anterior adductor muscle scar deep, oval-trianguloid, serrated. Pedal protractor muscle scar elliptical, compressed, and located behind anterior adductor muscle scar. Anterior pedal retractor muscle scar defined. Posterior adductor muscle scar unknown. Pallial line distinct.

Discussion:—In the shape of shell outline, the new species is very similar to *Cuneopsis maxima*, a species reported from the Early Pleistocene Sanmen Formation in Shanxi Province (Odhner, 1925; Leroy, 1940; Otuka, 1940), and from the Early Pleistocene Nihowan Formation in Qingshuihe, Hei Monggol Province (Zhu, 1976, 1940). *Cuneopsis praemaxima* differs from *C. maxima* in having a smaller shell, more anteriorly situated beaks, no beak sculpture, and narrower a hinge plate. The shell shape suggests its relationship with *Cuneopsis maxima*, which has been considered to be an ancestor of three Recent species, *Cuneopsis heudei*, *C. piscicula*, and *C. capitata* (Odhner, 1925). I believe that *Cuneopsis maxima* is also a descendant of *C. praemaxima*.

The Recent species *Cuneopsis piscicula* (Heude) distributed in Anhui, Zhejiang, Jiangsu, Jiangxi, Hubei and Hunan Provinces in China, has a twisted shell similar to that of *C. praemaxima*, but it differs from the present species having a shorter elliptical shell.

Measurements (in mm):—

	Length	Height	Width
ESN-40081 (holotype)	79.1	34.3	19.4
MFM-110018 (paratype 1)	65.8	40.1	26.3

Stratigraphic range: Ohyamada Clays of Iga Formation.

Occurrence: Localities 3 (I4b) and 6 (I25).

Acknowledgments

I am grateful to Professor J. Itoigawa of Nagoya University for reading the manuscript and offering valuable suggestions. I wish to thank Mr. S. Okuyama for placing those fossil bivalves from the Iga Formation at my disposal, and Professor B. Huang of Nanjing Institute of Geology and Palaeontology for providing the literature used in this study.

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Aitagawa 愛田川, Ayama 阿山, Fukazuki 深月, Hasuike 蓮池, Hata 畑, Hattorigawa 服部川, Hirata 平田, Hojiro 喰代, Iga 伊賀, Kashikimura 炊村, Kitamatsuura 北松浦, Kobiwako 古琵琶湖, Koka 甲賀, Koura 古浦, Kume 久米, Kurosaki 黒崎, Nakamura 中村, Nojima 野島, Sajigawa 佐治川, Ohyamada 大山田, Ueno 上野.

三重県伊賀累層からの鮮新世淡水棲二枚貝 *Lamprotula* と*Cuneopsis*：古琵琶湖層群下部の伊賀累層は，日本の鮮新統の中で独特の淡水棲動植物化石を産出することで知られている。特に貝類は豊富で，未記載種を含む20種以上の種からなり，伊賀非海生動物群の主体をなしている。今回，イシガイ科のガマノセガイ属とクサビイシガイ属に属する3新種を含む6種を記載した。それらは *Lamprotula* (*Sinolamprotula*) sp. A, *L.* (*Parunio*) sp. B, *L.* sp., *Cuneopsis* (*Cuneopsis*) *gracilenta*, n. sp., *C.* (*Procuneopsis*) *okuyamai*, n. sp., *C.* (*Tchangsinaia*) *praemaxima*, n. sp.である。*Lamprotula* と*Cuneopsis* 両属は，現在日本には生息せず，主に中国に分布している。また，これらは日本の鮮新統からの最初の報告である。

松岡敬二

PROCEEDINGS OF THE PALAEONTOLOGICAL SOCIETY OF JAPAN

日本古生物学会1988年年会・総会

日本古生物学会年会・総会が1988年1月28日～30日に東京学芸大学で開催された（参加者250名）。

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……………………………金沢謙一
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……………………………石垣　忍
パレオパラドキシアの食性について
…………久家直之・三枝春生・亀井節夫
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…………田吹亮一・中野孝之・野原朝秀
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……………村上汐里・山口寿之
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古海洋学ワークショップ…………世話人　鎮西清高
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小　集　会

タフォノミーを考える
……………世話人　安藤寿男・近藤康生

New members approved by the Council Meeting held on January 27, 1988

Ordinary Members:

Baba, Kenji; Inoue, Keisuke; Kamikawa, Yoichi; Morino, Yoshihiro; Okuyama, Shigemi; Shin, Jai Hoon; Yamaguchi, Keiko.

New fellows approved:

Akamatsu, Morio; Ando, Hisao; Kawamura, Yoshinari; Kikuchi, Yoshibumi; Hada, Shigeki; Hase, Yoshitaka; Makino, Tooru; Nishiwaki, Niichi; Sato, Yoshio; Tanaka, Kunio; Tanimura Yoshihiro; Tsugo, Yoshihiro; Yasuda, Hisato.

Withdrawing members:

Sawamura, Konosuke; Yoshida, Michio; Maeda, Shiro; Siida Isao; Talent, John A.; Jordan, Reiner; Loeblich, Alfred R., Jr.

Deceased Member:

Takahashi, Eitaro (August 20, 1987)

Errata

No. 148, 844. KOJIMA, Satoru and MIZUTANI, Shinjiro:
Triassic and Jurassic Radiolaria from the Nadanhada Range, Northeast China

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258	left	34	(delete)	fusulinaceans
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No. 148, 847. KONDO Yasuo:
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行事予定

	開催地	開催日	講演申込締切日
1988年第137回例会	福島県立博物館	1988年6月25日～26日	1988年4月10日
1989年年会・総会	京都大学	1989年2月3日～5日	1988年11月17日
1989年第138回例会	長崎大学	1989年6月	

講演申込先：〒113 東京都文京区弥生2-4-16
日本学会事務センター
日本古生物学会行事係（葉書で申し込んで下さい）

1989年年会・総会では「機能形態に関するシンポジューム」
世話人・鎮西清高が予定されています。

○文部省科学研究費補助金（研究成果公開促進費）による。

1988年4月25日　印刷
1988年4月30日　発行

ISSN 0031-0204
日本古生物学会報告・紀事
新篇149号
2,500円

発行者　日本古生物学会
文京区弥生2-4-16
日本学会事務センター内
（振替口座　東京　84780番）
（電話 03—817—5801）
編集者　猪郷久義・斎藤常正
編集幹事　野田浩司
印刷者　東京都練馬区豊玉北2の13
学術図書印刷株式会社　富田　潔
（電話 03—991—3754）

Transactions and Proceedings of the Palaeontological
Society of Japan

New Series No. 149 April 30, 1988

CONTENTS